



## Millimeter waves alter DNA secondary structures and modulate the transcriptome in human fibroblasts: supplement

**NICHOLAS B. LAWLER,<sup>1,2</sup>  CAMERON W. EVANS,<sup>2</sup> SERGII ROMANENKO,<sup>3</sup>  NUTAN CHAUDHARI,<sup>2</sup> MARK FEAR,<sup>4</sup> FIONA WOOD,<sup>5</sup> NICOLE M. SMITH,<sup>2,6</sup> VINCENT P. WALLACE,<sup>1,7</sup> AND K. SWAMINATHAN IYER<sup>2,8</sup>**

<sup>1</sup>*Department of Physics, The University of Western Australia, Perth, WA 6009, Australia*

<sup>2</sup>*School of Molecular Sciences, The University of Western Australia, Perth, WA 6009, Australia*

<sup>3</sup>*Department of Sensory Signaling, O.O. Bogomolets Institute of Physiology, National Academy of Sciences of Ukraine, Kyiv, 01601, Ukraine*

<sup>4</sup>*Burn Injury Research Unit, School of Biomedical Sciences, University of Western Australia, Perth, WA 6009, Australia*

<sup>5</sup>*Fiona Stanley and Princess Margaret Hospitals, Burns Service of Western Australia, Perth, WA, Australia*

<sup>6</sup>*nicole.smith@uwa.edu.au*

<sup>7</sup>*vincent.wallace@uwa.edu.au*

<sup>8</sup>*swaminatha.iyer@uwa.edu.au*

---

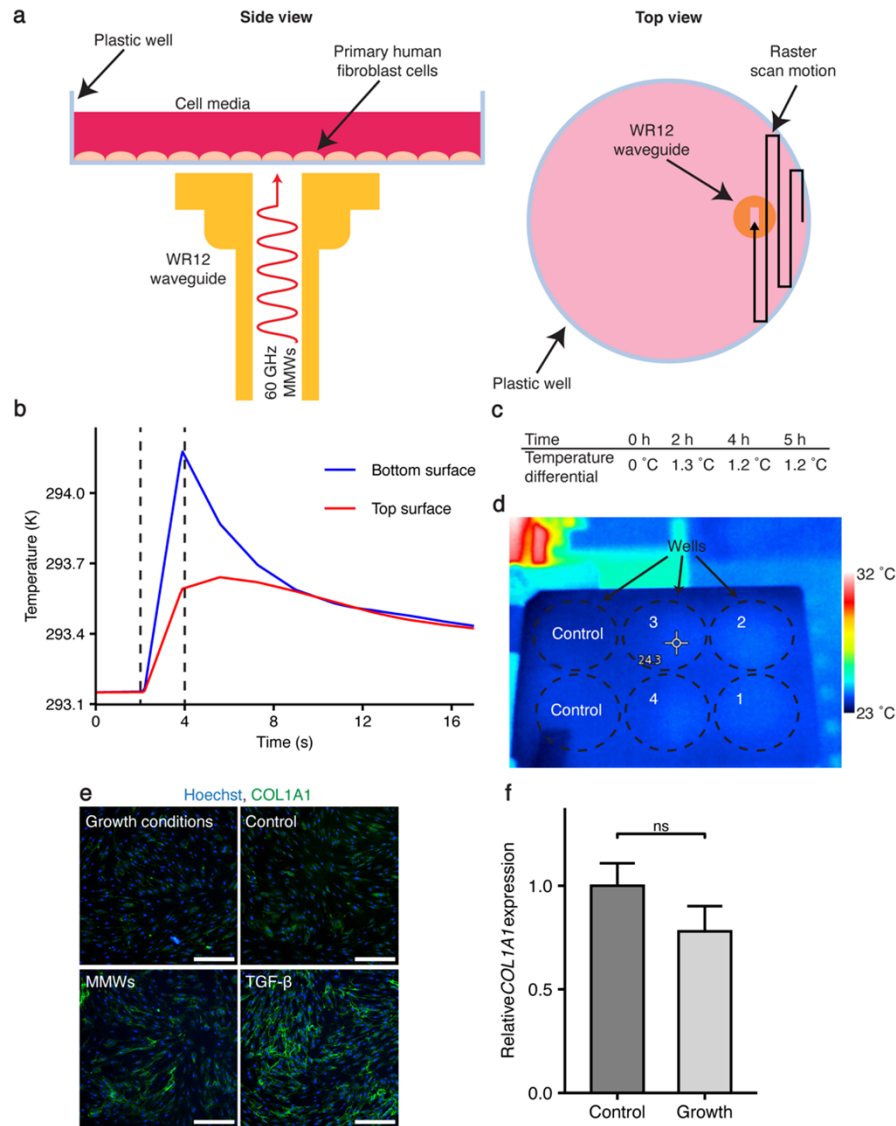
This supplement published with Optica Publishing Group on 28 April 2022 by The Authors under the terms of the [Creative Commons Attribution 4.0 License](https://creativecommons.org/licenses/by/4.0/) in the format provided by the authors and unedited. Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI.

Supplement DOI: <https://doi.org/10.6084/m9.figshare.19609407>

Parent Article DOI: <https://doi.org/10.1364/BOE.458478>

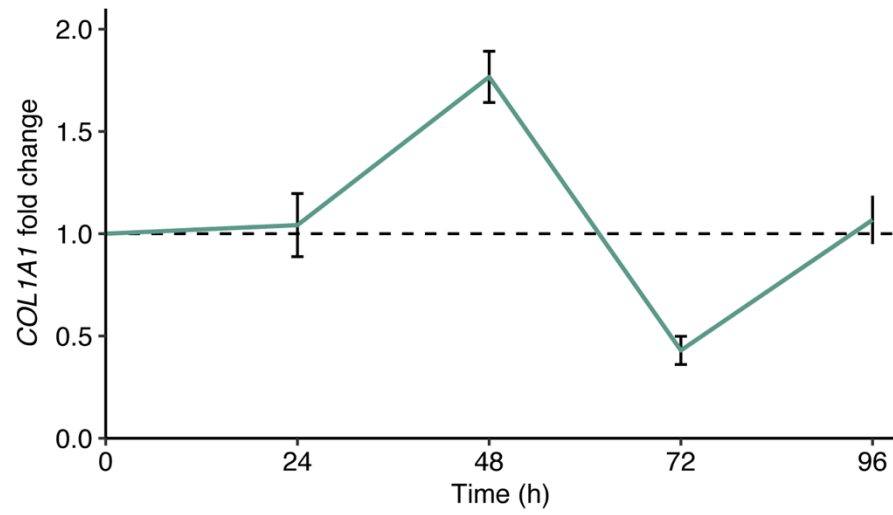
# Millimeter waves alter DNA secondary structures and modulate the transcriptome in human fibroblasts

## Supplemental Figures

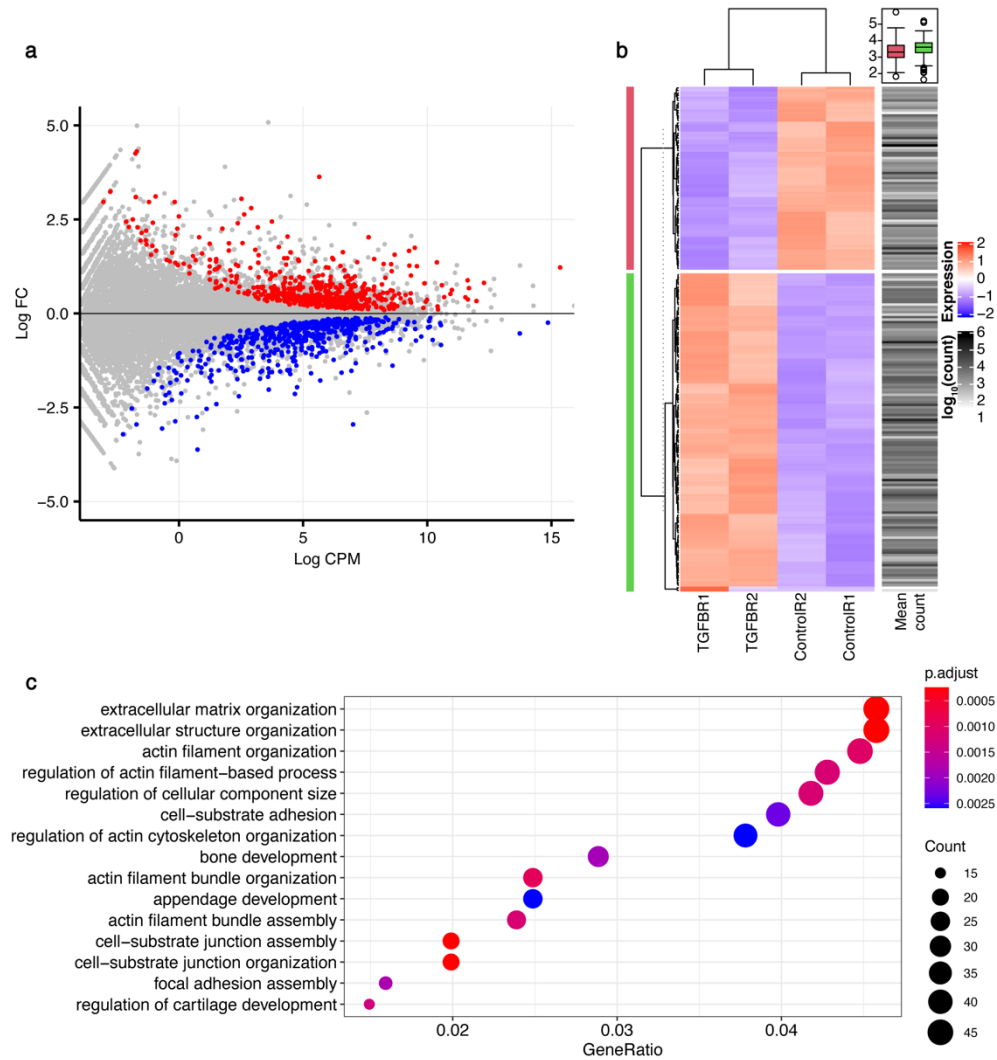


**Fig. S1. MMWs cause negligible thermal effects and cell controls do not differ significantly from growth conditions.** (a) Experimental setup of the MMW exposure. (b) Computational modelling of the temperature of the top and bottom surface of cell growth media during raster scan MMW exposure. The dashed lines at  $t = 2$  s and  $4$  s represent the start and end of the period of the raster scan where the simulated point in the well is above the MMW beam (c) Temperature differential between MMW exposed and control wells of the 6-well plate measured by a thermal probe after 0, 2, 4 and 5 h of MMW exposure. (d) Infrared image of the MMW exposed cells in a 6-well after 5 h shows heating of the most recently exposed well (well 2) and currently exposed cell (well 3) is only  $1$  °C. The raster scan passes the 4 numbered wells over the MMW beam in numerical order and repeats once the cycle is complete. (e) Representative fluorescent images

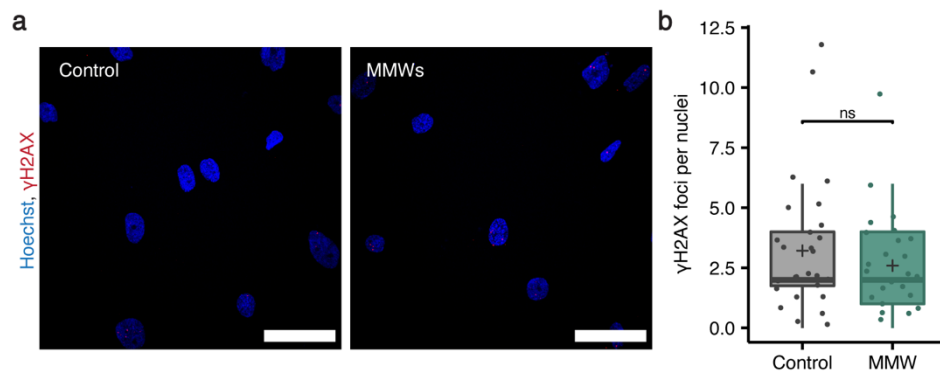
of day 4 fibroblasts in growth and control conditions, MMW exposed, and TGF- $\beta$  treated primary human fibroblasts stained with a COL1A1 specific antibody (green) shows no difference in collagen deposition in growth and control conditions (green: COL1A1, blue: nuclei, Hoechst 34580; magnification: 10x; numerical aperture: 0.45; scale bar: 300  $\mu$ m). (f) Relative expression of COL1A1 mRNA after 2 days in either control or growth conditions, determined via qPCR. Data is represented by mean  $\pm$  SEM from three biological replicates (n = 3).



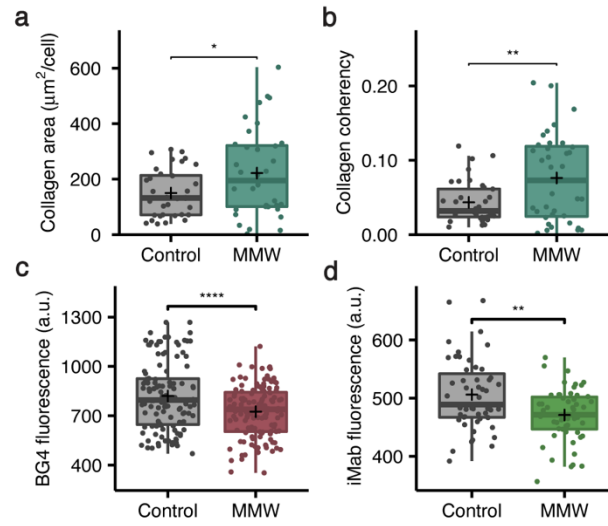
**Fig. S2. MMWs cause time-dependent modification to COL1A1 expression.** Relative expression of COL1A1 mRNA over time, characterised by qPCR. Data is represented as mean  $\pm$  SEM. 1 biological replicate.



**Fig. S3. Transcriptomic modifications induced by TGF- $\beta$  treatment.** (a) MD plot reveals the log fold change and average abundance of each gene, with significantly differentially expressed (FDR < 0.05) genes shown in red (upregulated) and blue (downregulated). (b) Heatmap showing relative expression and abundance of the top 200 differentially expressed genes. Color from blue to red corresponds to the relative expression levels, while the intensity of the mean count column indicates the average abundance of the gene. (c) Dot plot of gene ontology (GO) analysis of differentially expressed genes in TGF- $\beta$  treated fibroblasts plotted against gene ratio. Color indicates the p-value of the pathway and dot size corresponds to the number of DEGs in each pathway.



**Fig. S4. MMWs do not induce DNA damage.** (a) Representative confocal images of nuclei stained with a  $\gamma$ H2AX specific antibody (red:  $\gamma$ H2AX, blue: nuclei, Hoechst 34580; magnification: 60x; numerical aperture: 1.4; scale bar: 50  $\mu$ m). (b) Number of  $\gamma$ H2AX foci per nucleus ( $n \geq 25$  nuclei per condition). The thick center line represents the median and the black cross the mean for each sample.



**Fig. S5. Alternative box plot data representations showing individual datapoints.** For (a) Fig. 1b, (b) Fig. 1c, (c) Fig. 4c and (d) Fig. 4d. Data has been represented as box plots in which the black cross represents the mean, the thick center line is the median and the lower and upper horizontal lines of the box are the first and third quartiles, respectively. The upper whisker extends from the hinge to the largest value no further than  $1.5 \times$  the interquartile range (IQR) from the third quartile and the lower to the smallest value at most  $1.5 \times$  IQR of the first quartile.

## SUPPLEMENTAL TABLES

**Table S1. Genes associated with heat shock proteins or heat shock related biological pathways.**

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000109971	HSPA8	0	-0.115	49659.08	45841.63
ENSG00000110713	NUP98	0.078390894	-0.125	5618.32	5152.60
ENSG00000165280	VCP	0.311349344	-0.094	20217.03	18947.21
ENSG00000167792	NDUFV1	0.547746854	-0.171	3751.24	3332.13
ENSG00000119013	NDUFB3	0.57066261	-0.270	1000.52	829.40
ENSG00000140740	UQCRC2	0.74478869	-0.163	3306.95	2952.62
ENSG00000140990	NDUFB10	0.748339055	-0.148	2014.82	1818.32
ENSG00000126267	COX6B1	0.824132616	-0.145	2372.89	2146.33
ENSG00000110717	NDUFS8	0.857985258	-0.153	1531.25	1377.00
ENSG00000117748	RPA2	0.873687454	-0.209	945.38	817.74
ENSG00000175054	ATR	0.890916474	0.158	1649.56	1840.96
ENSG00000115520	COQ10B	0.895505769	0.285	1632.35	1989.07
ENSG00000198840	MT-ND3	0.906659025	1.075	60.02	127.42
ENSG00000069248	NUP133	0.908674662	-0.117	2728.80	2516.19
ENSG00000155561	NUP205	0.951137951	-0.124	2227.89	2044.07
ENSG00000132622	HSPA12B	0.95875332	1.060	5.79	13.00
ENSG00000149311	ATM	0.961571802	0.121	5210.34	5667.95
ENSG00000128609	NDUFA5	0.963298306	0.289	933.48	1140.82
ENSG00000004478	FKBP4	0.964354311	-0.202	1645.13	1429.91
ENSG00000198793	MTOR	0.969265482	-0.095	3784.70	3544.13
ENSG00000178449	COX14	0.971836844	0.308	523.78	648.45
ENSG00000204388	HSPA1B	0.972973939	0.231	7.83	9.34
ENSG00000198695	MT-ND6	0.973695104	0.633	13.79	21.87
ENSG00000203667	COX20	0.975163982	-0.386	656.04	501.98
ENSG00000170906	NDUFA3	0.975389632	-0.334	500.70	397.04
ENSG00000151366	NDUFC2	0.975765613	0.380	351.12	457.03
ENSG00000073578	SDHA	0.976407747	-0.258	453.78	379.28
ENSG00000105379	ETFB	0.980305746	-0.199	561.16	488.76
ENSG00000163626	COX18	0.980404378	0.223	535.60	625.45
ENSG00000156735	BAG4	0.980512772	0.139	1037.89	1142.67
ENSG00000204389	HSPA1A	0.983969796	0.149	11.20	12.52
ENSG00000175567	UCP2	0.984649585	-0.318	35.49	28.30
ENSG00000152137	HSPB8	0.985192934	0.120	1354.31	1471.63
ENSG00000102900	NUP93	0.985594175	-0.200	1445.53	1258.28
ENSG00000198899	MT-ATP6	0.985882602	0.839	361.70	647.78
ENSG00000058404	CAMK2B	0.985938274	0.074	33.72	35.53
ENSG00000174886	NDUFA11	0.98708747	-0.235	276.56	234.84
ENSG00000109390	NDUFC1	0.989193607	-0.295	510.12	415.70
ENSG00000167283	ATP5MG	0.989702351	0.294	404.61	496.17
ENSG00000115286	NDUFS7	0.989842033	-0.197	1017.09	887.16
ENSG00000125375	DMAC2L	0.989949153	0.234	133.09	156.67



Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000094914	AAAS	0.99106578	-0.246	1050.70	886.08
ENSG00000105993	DNAJB6	0.991568635	0.099	2672.44	2862.15
ENSG00000127540	UQCR11	0.991861106	0.204	320.36	369.20
ENSG00000112208	BAG2	0.992432171	0.245	1608.57	1906.05
ENSG00000177646	ACAD9	0.993122278	-0.124	1429.00	1311.23
ENSG00000168259	DNAJC7	0.993491562	-0.112	1874.58	1734.75
ENSG00000108559	NUP88	0.993799929	-0.114	986.33	911.48
ENSG00000145494	NDUFS6	0.994077236	-0.144	434.80	393.46
ENSG00000153291	SLC25A27	0.994119187	-0.013	145.20	143.88
ENSG00000082701	GSK3B	0.994157369	0.190	4032.31	4600.01
ENSG00000173660	UQCRH	0.994187639	-0.176	2860.38	2532.00
ENSG00000137806	NDUFAF1	0.994300542	-0.194	596.94	521.71
ENSG00000105821	DNAJC2	0.994530974	-0.132	435.08	397.05
ENSG00000164919	COX6C	0.994705019	-0.089	2318.36	2179.83
ENSG00000148660	CAMK2G	0.994830144	-0.134	2267.57	2065.80
ENSG00000136243	NUP42	0.994836113	0.133	458.36	502.63
ENSG00000117118	SDHB	0.994857937	-0.095	2008.94	1881.48
ENSG00000139496	NUP58	0.994977107	-0.112	1892.14	1750.59
ENSG00000058804	NDC1	0.995018965	-0.173	806.04	715.06
ENSG00000111581	NUP107	0.995029019	-0.113	1074.59	993.30
ENSG00000164405	UQCRQ	0.995238987	-0.085	2193.29	2068.34
ENSG00000198763	MT-ND2	0.99526816	0.604	252.18	383.69
ENSG00000151929	BAG3	0.995360404	0.121	1616.48	1757.77
ENSG00000136463	TACO1	0.995403917	-0.102	580.65	541.12
ENSG00000178741	COX5A	0.995493827	0.123	901.47	981.53
ENSG00000241468	ATP5MF	0.995541112	-0.128	776.51	710.63
ENSG00000164182	NDUFAF2	0.995595362	-0.035	406.89	397.24
ENSG00000166260	COX11	0.995887683	-0.092	902.48	846.83
ENSG00000093000	NUP50	0.995959626	-0.095	2257.94	2113.59
ENSG00000167965	MLST8	0.995968228	-0.127	1126.22	1031.53
ENSG00000003509	NDUFAF7	0.995997035	0.082	614.80	650.61
ENSG00000119421	NDUFA8	0.996017667	-0.053	533.23	513.94
ENSG00000153201	RANBP2	0.996129355	0.108	8709.82	9384.88
ENSG00000187051	RPS19BP1	0.996195276	-0.101	1977.29	1843.30
ENSG00000102078	SLC25A14	0.99625821	-0.098	264.72	247.28
ENSG00000099624	ATP5F1D	0.996327604	-0.001	509.00	508.65
ENSG00000213024	NUP62	0.996333408	-0.136	1375.99	1251.93
ENSG00000198888	MT-ND1	0.99642338	0.499	532.40	752.63
ENSG00000004779	NDUFAB1	0.996515465	-0.078	962.76	911.75
ENSG00000075188	NUP37	0.996529842	-0.035	673.54	657.54
ENSG00000101146	RAE1	0.996707112	0.073	1028.99	1082.55
ENSG00000165264	NDUFB6	0.996756239	-0.052	843.61	813.98
ENSG00000169020	ATP5ME	0.996831541	0.070	1259.23	1322.28
ENSG00000183648	NDUFB1	0.996897139	0.064	953.56	997.09

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000096384	HSP90AB1	0.996900445	-0.160	27490.55	24606.49
ENSG00000171503	ETFDH	0.996925011	-0.035	851.40	831.24
ENSG00000284194	SCO2	0.996931987	0.022	830.17	843.22
ENSG00000130159	ECSIT	0.996956528	-0.014	811.61	803.91
ENSG00000126803	HSPA2	0.997042945	0.084	660.21	699.66
ENSG00000145349	CAMK2D	0.997054956	0.099	5749.77	6157.52
ENSG00000101247	NDUFAF5	0.997058738	-0.054	394.48	379.96
ENSG00000143252	SDHC	0.997081022	-0.056	1157.35	1113.07
ENSG00000109846	CRYAB	0.997118279	-0.092	1752.91	1644.53
ENSG00000184752	NDUFA12	0.997145886	-0.003	728.54	726.81
ENSG00000120253	NUP43	0.997265722	-0.052	1372.06	1323.34
ENSG00000158864	NDUFS2	0.997274833	-0.109	1725.04	1599.13
ENSG00000196313	POM121	0.997283142	-0.009	1048.55	1041.85
ENSG00000096717	SIRT1	0.99728329	0.071	1277.09	1341.55
ENSG00000213619	NDUFS3	0.997313088	-0.034	1112.12	1085.95
ENSG00000102882	MAPK3	0.997319406	-0.007	1047.12	1042.29
ENSG00000167863	ATP5PD	0.99735456	-0.106	3342.93	3106.09
ENSG00000138750	NUP54	0.997364432	-0.035	1186.73	1158.53
ENSG00000085415	SEH1L	0.99738342	0.024	1059.42	1077.04
ENSG00000148290	SURF1	0.997386282	0.027	639.01	651.22
ENSG00000115944	COX7A2L	0.997393628	0.085	2553.51	2709.24
ENSG00000176340	COX8A	0.997397507	0.062	1124.82	1173.97
ENSG00000135390	ATP5MC2	0.997421912	-0.097	2334.30	2182.24
ENSG00000010256	UQCRC1	0.997516925	-0.161	4223.72	3778.58
ENSG00000154518	ATP5MC3	0.997564535	-0.124	2356.25	2161.76
ENSG00000198786	MT-ND5	0.997577568	0.489	890.35	1249.78
ENSG00000131174	COX7B	0.997628669	0.006	1310.48	1315.66
ENSG00000171204	TMEM126B	0.997636883	0.025	1003.87	1021.25
ENSG00000187522	HSPA14	0.997674394	0.010	466.17	469.54
ENSG00000136521	NDUFB5	0.997692045	0.021	1461.79	1483.70
ENSG00000168653	NDUFS5	0.997704919	-0.094	2564.01	2402.44
ENSG00000165868	HSPA12A	0.997724261	0.189	1298.71	1481.03
ENSG00000005339	CREBBP	0.997731666	0.222	3266.59	3810.72
ENSG00000169021	UQCRC1	0.99775122	-0.069	2187.05	2084.15
ENSG00000158941	CCAR2	0.997752266	-0.063	2060.07	1971.59
ENSG00000156467	UQCRB	0.997756578	0.100	3480.67	3729.86
ENSG00000125356	NDUFA1	0.997791504	0.065	1524.89	1595.42
ENSG00000099795	NDUFB7	0.997824185	-0.042	1546.83	1502.25
ENSG00000132383	RPA1	0.997832078	0.041	1792.98	1844.84
ENSG00000189043	NDUFA4	0.997849917	-0.088	2568.81	2417.03
ENSG00000130414	NDUFA10	0.997870041	-0.068	2280.20	2174.65
ENSG00000159199	ATP5MC1	0.997882219	-0.038	605.79	590.21
ENSG00000113569	NUP155	0.997916482	0.013	1595.50	1610.35
ENSG00000141564	RPTOR	0.997929708	0.011	1822.42	1835.87

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000065518	NDUFB4	0.997935496	0.002	1476.24	1477.98
ENSG00000116459	ATP5PB	0.998004067	-0.053	4164.99	4015.54
ENSG00000126602	TRAP1	0.998021319	-0.012	1198.59	1188.49
ENSG00000131495	NDUFA2	0.998098608	0.004	824.41	826.94
ENSG00000095319	NUP188	0.99814162	0.037	2519.57	2584.16
ENSG00000030066	NUP160	0.998196526	0.065	2495.57	2611.50
ENSG00000127184	COX7C	0.998250528	-0.034	2207.04	2154.97
ENSG00000126883	NUP214	0.998277878	-0.013	1359.96	1347.45
ENSG00000165629	ATP5F1C	0.998278622	-0.058	2960.70	2843.66
ENSG00000172115	CYCS	0.998305891	0.021	1870.50	1898.59
ENSG00000185122	HSF1	0.998314065	-0.021	2241.81	2209.69
ENSG00000135940	COX5B	0.998343295	-0.064	2700.50	2583.58
ENSG00000106399	RPA3	0.998352696	0.014	400.05	403.99
ENSG00000125450	NUP85	0.99837282	-0.060	749.17	718.66
ENSG00000198886	MT-ND4	0.99837887	0.500	1209.48	1710.92
ENSG00000155304	HSPA13	0.998386353	-0.002	2758.40	2753.76
ENSG00000113845	TIMMDC1	0.998387211	-0.020	2721.37	2683.14
ENSG00000164070	HSPA4L	0.998391982	0.093	1501.23	1600.80
ENSG00000157020	SEC13	0.998424364	0.081	5708.58	6036.93
ENSG00000124172	ATP5F1E	0.998460311	0.057	4717.03	4906.45
ENSG00000154723	ATP5PF	0.998591247	-0.031	720.32	705.08
ENSG00000132002	DNAJB1	0.998603175	-0.035	3738.33	3647.49
ENSG00000110955	ATP5F1B	0.998651113	-0.096	12087.10	11307.30
ENSG00000047410	TPR	0.998682971	-0.035	7813.98	7625.81
ENSG00000230989	HSBP1	0.998685707	-0.011	3885.65	3855.94
ENSG00000131143	COX4I1	0.998699306	0.025	4435.30	4514.30
ENSG00000198727	MT-CYB	0.998723743	0.624	2099.75	3236.05
ENSG00000108953	YWHAE	0.998742752	0.008	3803.38	3825.30
ENSG00000120694	HSPH1	0.998747725	0.021	4842.78	4913.16
ENSG00000110958	PTGES3	0.998795772	0.050	4018.22	4158.76
ENSG00000138095	LRPPRC	0.998854467	-0.035	5732.78	5596.21
ENSG00000162889	MAPKAPK2	0.998907017	0.010	5381.69	5420.19
ENSG00000100393	EP300	0.998907852	0.083	4540.42	4810.32
ENSG00000170606	HSPA4	0.998983166	-0.005	7587.41	7560.17
ENSG00000100030	MAPK1	0.999057258	0.018	8856.68	8968.16
ENSG00000156170	NDUFAF6	0.999063885	0.034	211.49	216.51
ENSG00000198712	MT-CO2	0.999147878	0.312	3753.89	4660.56
ENSG00000100380	ST13	0.999151691	-0.033	10494.54	10254.76
ENSG00000044574	HSPA5	0.999163307	0.030	5907.08	6031.28
ENSG00000184076	UQCR10	0.999259615	0.004	945.66	948.57
ENSG00000147684	NDUFB9	0.999287523	0.014	1501.76	1515.98
ENSG00000113013	HSPA9	0.999324165	-0.074	10470.84	9948.63
ENSG00000152234	ATP5F1A	0.999328786	-0.090	14995.00	14084.78
ENSG00000094631	HDAC6	0.99933103	-0.011	1640.86	1628.23

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000080824	HSP90AA1	0.999456066	0.004	12592.12	12629.45
ENSG00000198938	MT-CO3	0.999673494	-0.022	17908.36	17631.49
ENSG00000198804	MT-CO1	0.999849043	0.186	48109.61	54730.29
ENSG00000178057	NDUFAF3	0.999868567	-0.085	1092.96	1030.61
ENSG00000204370	SDHD	0.999870329	-0.021	1314.52	1295.47
ENSG00000156508	EEF1A1	0.999932361	-0.031	348293.25	340948.01
ENSG00000179091	CYC1	0.999999998	-0.244	1933.38	1632.78
ENSG00000166170	BAG5	0.999999999	0.221	1958.41	2283.32
ENSG00000204673	AKT1S1	1	0.291	853.54	1044.39
ENSG00000090266	NDUFB2	1	-0.182	1501.61	1323.21
ENSG00000070808	CAMK2A	1	-0.940	51.28	26.31
ENSG00000111775	COX6A1	1	-0.184	1063.48	935.85
ENSG00000124789	NUP153	1	0.106	2443.65	2630.28
ENSG00000163002	NUP35	1	0.298	179.79	221.19
ENSG00000107262	BAG1	1	-0.093	1921.36	1801.96
ENSG00000149196	HIKESHI	1	0.089	904.30	961.72
ENSG00000173110	HSPA6	1	-0.061	25.80	24.71
ENSG00000139180	NDUFA9	1	-0.249	301.15	253.35
ENSG00000186010	NDUFA13	1	0.154	23.04	25.74
ENSG00000241837	ATP5PO	1	0.064	366.59	383.25
ENSG00000178127	NDUFV2	1	0.193	61.76	70.71
ENSG00000123545	NDUFAF4	1	0.103	285.87	307.00
ENSG00000164258	NDUFS4	1	-0.074	1282.11	1218.35
ENSG00000147123	NDUFB11	1	-0.053	1864.12	1796.56
ENSG00000023228	NDUFS1	1	-0.075	5794.76	5500.22
ENSG00000166136	NDUFB8	1	-0.023	212.17	208.76
ENSG00000135469	COQ10A	1	-0.169	388.63	345.57
ENSG00000133028	SCO1	1	0.049	1084.28	1121.88
ENSG00000133983	COX16	1	0.481	37.29	52.39
ENSG00000140374	ETFA	1	-0.045	2046.17	1983.32
ENSG00000151413	NUBPL	1	-0.001	315.91	315.58
ENSG00000160194	NDUFV3	1	-0.061	1213.34	1162.75
ENSG00000175564	UCP3	1	0.380	29.16	38.20
ENSG00000184983	NDUFA6	1	-0.144	1070.84	968.97

**Table S2. Pathway analysis of the top 20 DEGs, filtered for pathways involving  $\geq 3$  DEGs.**

<b>Pathway ID</b>	<b>Pathway description</b>	<b>Gene IDs</b>	<b>Genes</b>
GO:0005925	focal adhesion	HSPA8/LPXN/AKAP12/ITGAV/SCARB2	5
GO:0030055	cell-substrate junction	HSPA8/LPXN/AKAP12/ITGAV/SCARB2	5
GO:0043254	regulation of protein-containing complex assembly	HSPA8/CAMSAP2/JMY/DDX3X	4
GO:0007050	cell cycle arrest	IRF1/PLK2/JMY	3
GO:0072331	signal transduction by p53 class mediator	TWIST1/PLK2/JMY	3
GO:0050663	cytokine secretion	TWIST1/AKAP12/ITGAV	3
GO:0007059	chromosome segregation	NCAPD2/SMC2/DDX3X	3
GO:0071214	cellular response to abiotic stimulus	GPR68/IRF1/DDX3X	3
GO:0104004	cellular response to environmental stimulus	GPR68/IRF1/DDX3X	3
GO:1902903	regulation of supramolecular fiber organization	HSPA8/CAMSAP2/JMY	3
GO:0071103	DNA conformation change	NCAPD2/SMC2/DDX3X	3
GO:0019058	viral life cycle	ITGAV/SCARB2/DDX3X	3
GO:0006605	protein targeting	HSPA8/AKAP12/SCARB2	3
GO:0001667	ameboidal-type cell migration	TWIST1/AKAP12/PLK2	3

**Table S3. Differentially expressed genes in MMW-exposed primary human fibroblasts.**

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG0000010292	NCAPD2	0	-0.417	3288.80	2462.42
ENSG00000091527	CDV3	0	0.234	7362.70	8660.31
ENSG00000109971	HSPA8	0	-0.115	49659.08	45841.63
ENSG00000110031	LPXN	0	-0.304	4245.03	3437.78
ENSG00000119714	GPR68	0	-0.387	2908.61	2223.68
ENSG00000125347	IRF1	0	0.484	3083.19	4312.13
ENSG00000131016	AKAP12	0	0.401	4998.72	6601.11
ENSG00000136824	SMC2	0	-0.510	1662.34	1167.25
ENSG00000138760	SCARB2	0	0.126	15368.47	16774.13
ENSG00000169504	CLIC4	0	0.205	21766.00	25091.46
ENSG00000118200	CAMSAP2	2.22E-16	0.232	3697.84	4342.38
ENSG00000145632	PLK2	6.66E-16	0.345	3878.59	4928.15
ENSG00000122691	TWIST1	1.67E-15	0.268	2889.26	3478.10
ENSG00000152409	JMY	2.00E-15	0.316	2558.20	3185.48
ENSG00000177156	TALDO1	8.66E-15	-0.211	6267.15	5415.82
ENSG00000154930	ACSS1	3.20E-14	0.863	178.80	325.91
ENSG00000182463	TSHZ2	3.61E-14	0.265	2578.63	3098.04
ENSG00000138448	ITGAV	7.33E-14	0.171	13802.65	15536.32
ENSG00000215301	DDX3X	8.74E-14	0.250	16816.80	19999.95
ENSG00000099251	HSD17B7P2	1.50E-12	-1.256	187.92	78.16
ENSG00000163412	EIF4E3	7.82E-12	0.633	447.09	693.79
ENSG00000081154	PCNP	2.02E-11	0.208	3358.23	3880.51
ENSG00000108551	RASD1	3.35E-11	-0.601	536.96	353.80
ENSG00000122705	CLTA	3.35E-11	-0.159	6834.21	6119.40
ENSG00000101003	GINS1	5.34E-11	-1.050	189.06	90.85
ENSG00000189184	PCDH18	7.20E-11	0.224	23200.85	27089.28
ENSG00000127329	PTPRB	8.03E-11	0.445	1216.72	1656.80
ENSG00000177425	PAWR	1.38E-10	0.515	879.24	1257.17
ENSG00000182670	TTC3	2.38E-10	0.232	16888.95	19839.67
ENSG00000205189	ZBTB10	3.34E-10	0.361	1194.80	1534.88
ENSG00000180596	H2BC4	5.61E-10	-0.485	3434.56	2454.06
ENSG00000122591	FAM126A	6.08E-10	0.256	5496.74	6562.82
ENSG00000130962	PRRG1	1.56E-09	0.520	414.30	594.31
ENSG00000042753	AP2S1	2.40E-09	-0.247	3073.56	2589.35
ENSG00000073111	MCM2	3.28E-09	-0.461	1298.47	943.35
ENSG00000165475	CRYL1	5.14E-09	-0.661	401.06	253.25
ENSG00000174839	DENND6A	5.41E-09	0.426	794.29	1067.41
ENSG00000047644	WWC3	7.56E-09	0.203	2982.08	3432.01
ENSG00000122068	FYTTD1	1.93E-08	0.198	3008.58	3450.63
ENSG00000178996	SNX18	5.19E-08	0.254	4621.49	5511.92
ENSG00000171720	HDAC3	7.89E-08	-0.280	1838.38	1514.27
ENSG00000127586	CHTF18	1.02E-07	-0.661	325.95	205.84
ENSG00000161888	SPC24	1.07E-07	-1.055	406.49	195.14

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000211451	GNRHR2	1.12E-07	-3.022	31.90	3.17
ENSG00000196968	FUT11	2.62E-07	0.295	1848.69	2267.77
ENSG00000170962	PDGFD	2.68E-07	0.442	1319.41	1793.27
ENSG00000049541	RFC2	3.44E-07	-0.768	591.26	346.77
ENSG00000108518	PFN1	3.81E-07	-0.320	9445.39	7568.76
ENSG00000280383		3.93E-07	1.475	27.58	78.20
ENSG00000163946	TASOR	3.94E-07	0.212	3512.26	4067.93
ENSG00000120068	HOXB8	5.45E-07	-1.382	127.26	48.29
ENSG00000170779	CDCA4	7.01E-07	-0.481	569.71	407.98
ENSG00000198265	HELZ	7.18E-07	0.252	2664.48	3172.61
ENSG00000113240	CLK4	7.51E-07	-0.576	456.26	305.85
ENSG00000169967	MAP3K2	9.11E-07	0.180	3608.22	4086.97
ENSG00000161011	SQSTM1	1.00E-06	-0.248	66821.95	56270.69
ENSG00000182154	MRPL41	1.08E-06	-0.399	1266.18	960.15
ENSG00000137309	HMGA1	3.09E-06	-0.429	10018.99	7440.27
ENSG00000013275	PSMC4	3.23E-06	-0.273	2383.21	1972.59
ENSG00000138688	KIAA1109	3.25E-06	0.211	10232.82	11846.89
ENSG00000133997	MED6	3.48E-06	0.486	479.85	672.51
ENSG00000279861		4.21E-06	1.898	13.13	51.31
ENSG00000146223	RPL7L1	4.24E-06	-0.200	5027.15	4376.14
ENSG00000157593	SLC35B2	4.42E-06	-0.182	3556.63	3135.76
ENSG00000142230	SAE1	4.43E-06	-0.199	3649.04	3179.53
ENSG00000005448	WDR54	4.90E-06	-0.446	577.23	423.55
ENSG00000122642	FKBP9	5.18E-06	0.100	18302.16	19621.00
ENSG00000200087	SNORA73B	5.59E-06	0.669	767.89	1221.29
ENSG00000121766	ZCCHC17	6.27E-06	-0.397	869.88	660.57
ENSG00000143870	PDIA6	7.22E-06	-0.107	10206.75	9474.76
ENSG00000120705	ETF1	8.27E-06	0.156	5770.03	6428.13
ENSG00000117114	ADGRL2	8.37E-06	0.231	2271.95	2667.40
ENSG00000172175	MALT1	9.54E-06	0.245	2096.72	2484.69
ENSG00000276410	H2BC3	1.22E-05	-0.800	1237.76	710.36
ENSG00000101470	TNNC2	1.25E-05	-2.163	38.52	7.93
ENSG00000100629	CEP128	1.28E-05	-0.878	181.72	98.46
ENSG00000154380	ENAH	1.32E-05	0.203	3184.91	3666.33
ENSG00000156671	SAMD8	1.77E-05	0.183	2976.62	3379.51
ENSG00000125912	NCLN	1.85E-05	-0.286	2790.36	2287.99
ENSG00000172725	CORO1B	1.91E-05	-0.197	5235.44	4568.45
ENSG00000276045	ORAI1	2.00E-05	-0.578	465.38	311.38
ENSG00000102760	RGCC	2.17E-05	0.343	703.09	892.16
ENSG00000160746	ANO10	3.00E-05	-0.207	2962.26	2566.23
ENSG00000274425		3.50E-05	-1.259	85.61	35.27
ENSG00000174371	EXO1	4.19E-05	-0.766	254.48	149.24
ENSG00000090889	KIF4A	5.41E-05	-0.893	512.95	275.91
ENSG00000182150	ERCC6L2	6.07E-05	0.258	1358.71	1624.62

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000092853	CLSPN	6.84E-05	-0.696	305.96	188.49
ENSG00000142875	PRKACB	6.98E-05	0.360	1191.38	1528.95
ENSG00000197912	SPG7	7.70E-05	-0.165	3521.27	3141.08
ENSG00000197614	MFAP5	8.28E-05	0.239	3331.59	3933.12
ENSG00000118495	PLAGL1	8.75E-05	0.345	800.05	1016.35
ENSG00000167910	CYP7A1	0.000100828	3.426	0.92	18.31
ENSG00000166133	RPUSD2	0.000111806	-0.493	401.52	285.08
ENSG00000169895	SYAP1	0.000113207	0.146	4069.65	4503.16
ENSG00000144642	RBMS3	0.000126842	0.361	1737.45	2231.08
ENSG00000164597	COG5	0.000133923	0.247	1494.99	1773.99
ENSG00000170456	DENND5B	0.000142058	0.328	828.55	1040.11
ENSG00000047249	ATP6V1H	0.000151709	-0.193	2974.03	2602.43
ENSG00000197903	H2BC12	0.000159304	-0.260	3983.51	3325.71
ENSG00000144566	RAB5A	0.00016299	0.238	2183.34	2575.18
ENSG00000112851	ERBIN	0.000171752	0.220	6700.66	7805.14
ENSG00000114388	NPRL2	0.00018736	-0.420	555.66	415.01
ENSG00000144655	CSRNP1	0.000188339	0.295	2030.87	2491.95
ENSG00000178761	FAM219B	0.000219051	-0.209	3073.89	2658.46
ENSG00000123975	CKS2	0.000262376	-0.731	726.24	437.19
ENSG00000119333	DYNC2I2	0.000273457	-0.392	1655.13	1261.50
ENSG00000007944	MYLIP	0.00027487	0.454	1590.59	2178.47
ENSG00000056972	TRAF3IP2	0.000275467	-0.235	2460.71	2091.22
ENSG00000180573	H2AC6	0.000286136	-0.288	5108.88	4185.57
ENSG00000234456	MAGI2-AS3	0.000327226	0.341	1197.49	1517.14
ENSG00000188486	H2AX	0.000331385	-0.605	672.70	441.98
ENSG00000156970	BUB1B	0.000350277	-0.841	401.85	223.96
ENSG00000197780	TAF13	0.000352821	0.313	769.58	956.00
ENSG00000133110	POSTN	0.000371437	0.292	8641.29	10582.35
ENSG00000116161	CACYBP	0.000375846	-0.203	2307.38	2004.73
ENSG00000159592	GPBP1L1	0.000408739	-0.186	3403.06	2990.56
ENSG00000177707	NECTIN3	0.000423824	0.276	2430.04	2941.69
ENSG00000126903	SLC10A3	0.000448676	-0.358	1233.16	962.14
ENSG00000182934	SRPRA	0.000495004	-0.149	4956.36	4469.81
ENSG00000090316	MAEA	0.00053258	-0.193	2288.70	2001.36
ENSG00000277459		0.0005702	-3.647	16.60	0.53
ENSG00000123636	BAZ2B	0.000579858	0.222	1543.52	1800.94
ENSG00000144228	SPOPL	0.000580772	0.320	665.49	830.94
ENSG00000059769	DNAJC25	0.000599904	0.515	335.73	479.97
ENSG00000169223	LMAN2	0.000610514	-0.227	4643.74	3966.36
ENSG00000165494	PCF11	0.000614516	0.206	2236.68	2579.23
ENSG00000239713	APOBEC3G	0.000624341	-1.049	265.03	127.67
ENSG00000102362	SYTL4	0.000842532	-0.597	252.03	166.35
ENSG00000231530		0.000845385	3.408	0.94	18.31
ENSG00000166257	SCN3B	0.000919342	2.132	6.97	33.49



Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000167671	UBXN6	0.001065278	-0.199	5384.27	4691.41
ENSG00000204237	OXLD1	0.001189631	-0.368	607.55	470.59
ENSG00000138433	CIR1	0.001224937	0.464	406.32	560.70
ENSG00000249492		0.001276692	-3.220	17.06	1.06
ENSG00000107968	MAP3K8	0.001441755	0.392	802.73	1053.90
ENSG00000127914	AKAP9	0.001512949	0.160	2800.71	3129.62
ENSG00000182087	TMEM259	0.001559753	-0.271	3267.01	2706.68
ENSG00000108344	PSMD3	0.001612799	-0.197	3496.06	3050.28
ENSG00000143476	DTL	0.001660294	-0.935	459.94	240.10
ENSG00000165355	FBXO33	0.001661081	0.230	2044.37	2397.95
ENSG00000153094	BCL2L11	0.001673749	0.298	827.65	1017.76
ENSG00000166888	STAT6	0.001688267	-0.101	9313.84	8684.87
ENSG00000260000		0.001766563	1.540	15.83	47.68
ENSG00000075702	WDR62	0.001839966	-0.736	418.90	251.22
ENSG00000106052	TAX1BP1	0.001886585	0.117	5864.08	6359.45
ENSG00000179833	SERTAD2	0.001928853	0.440	3017.33	4094.58
ENSG00000197905	TEAD4	0.001965572	0.782	126.08	217.36
ENSG00000287378		0.001989608	1.852	8.99	34.70
ENSG00000196937	FAM3C	0.002222787	0.304	2178.58	2688.88
ENSG00000065328	MCM10	0.002239219	-0.895	138.11	73.86
ENSG00000122884	P4HA1	0.002301279	0.273	3621.37	4376.03
ENSG00000080503	SMARCA2	0.002594499	0.140	7861.32	8661.30
ENSG00000129219	PLD2	0.002839806	-0.252	1389.95	1167.02
ENSG00000167766	ZNF83	0.002905434	-0.283	1113.40	915.11
ENSG00000215271	HOMEZ	0.002949953	-0.422	443.89	331.10
ENSG00000254535	PABPC4L	0.003120501	1.008	62.50	126.60
ENSG00000228544	CCDC183-AS1	0.003227741	1.290	25.83	64.38
ENSG00000101945	SUV39H1	0.00330342	-0.939	279.56	145.35
ENSG00000134186	PRPF38B	0.003316199	0.315	678.64	844.51
ENSG00000085063	CD59	0.003434655	0.052	28798.19	29857.63
ENSG00000101654	RNMT	0.003683609	0.205	2153.42	2481.78
ENSG00000104872	PIH1D1	0.00374158	-0.255	1787.22	1497.58
ENSG00000051620	HEBP2	0.004116055	-0.209	1782.68	1542.47
ENSG00000027697	IFNGR1	0.004122644	0.230	2499.05	2930.42
ENSG00000182903	ZNF721	0.004761544	0.337	526.74	665.45
ENSG00000073756	PTGS2	0.005013198	0.424	4433.33	5950.10
ENSG00000102554	KLF5	0.005279522	1.216	145.90	340.04
ENSG00000185000	DGAT1	0.00529461	-0.460	537.48	390.63
ENSG00000225578	NCBP2-AS1	0.005501976	2.691	2.35	19.86
ENSG00000173272	MZT2A	0.005670919	-0.339	1086.34	858.87
ENSG00000258655	ARHGAP5-AS1	0.005756563	1.783	17.93	63.81
ENSG00000174695	TMEM167A	0.005793351	0.144	3165.09	3497.82
ENSG00000183597	TANGO2	0.005893314	-0.236	1731.80	1470.09
ENSG00000184897	H1-10	0.005957187	-0.308	2070.46	1671.95

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000126247	CAPNS1	0.005987746	-0.251	6135.92	5155.53
ENSG00000222112	RN7SKP16	0.006494578	-2.121	25.56	5.21
ENSG00000105486	LIG1	0.006664505	-0.384	827.13	633.49
ENSG00000240729		0.006701092	2.137	4.71	23.67
ENSG00000113594	LIFR	0.006949383	0.371	994.66	1286.99
ENSG00000124207	CSE1L	0.007346929	-0.277	2989.18	2466.52
ENSG00000135446	CDK4	0.007775496	-0.136	3940.79	3587.29
ENSG00000158125	XDH	0.007902956	-1.080	85.48	39.98
ENSG00000132763	MMACHC	0.007942065	-0.538	256.45	176.42
ENSG00000111530	CAND1	0.008433521	0.104	6181.41	6644.66
ENSG00000071189	SNX13	0.008489151	0.146	3176.34	3515.90
ENSG00000143333	RGS16	0.008647566	-0.521	306.53	213.41
ENSG00000161547	SRSF2	0.009042491	-0.270	2993.43	2482.61
ENSG00000148154	UGCG	0.00923699	0.686	1923.51	3095.17
ENSG00000166526	ZNF3	0.009500954	-0.289	891.58	729.52
ENSG00000184232	OAF	0.009808406	-0.345	2910.96	2292.33
ENSG00000180884	ZNF792	0.010264071	-0.571	317.31	213.27
ENSG00000154114	TBCEL	0.010559971	0.359	884.39	1134.71
ENSG00000114978	MOB1A	0.010849542	0.105	6329.65	6809.21
ENSG00000136720	HS6ST1	0.01167779	0.336	551.21	695.93
ENSG00000103061	SLC7A6OS	0.011695176	-0.390	591.17	450.89
ENSG00000131153	GINS2	0.012360899	-0.980	132.94	66.98
ENSG00000120328	PCDHB12	0.012525773	-1.291	51.50	20.53
ENSG00000134690	CDCA8	0.012649369	-0.788	193.49	111.70
ENSG00000177602	HASPIN	0.012793754	-0.646	191.50	122.04
ENSG00000168303	MPLKIP	0.013443908	0.520	227.03	325.94
ENSG00000129925	PGAP6	0.013450411	-0.151	3640.64	3278.91
ENSG00000246695	RASSF8-AS1	0.013510994	0.543	452.77	659.94
ENSG00000130749	ZC3H4	0.013670006	0.270	1143.43	1378.53
ENSG00000146373	RNF217	0.013919033	0.279	834.80	1012.77
ENSG00000166266	CUL5	0.013943981	0.244	1921.23	2276.07
ENSG00000151208	DLG5	0.01443676	0.141	3233.58	3566.87
ENSG00000248593	DSTNP2	0.014964553	-0.779	146.82	85.17
ENSG00000175287	PHYHD1	0.015749957	-0.687	222.47	137.86
ENSG00000286656		0.015925921	-2.542	40.69	6.27
ENSG00000275221	H2AC15	0.016505242	-0.801	305.36	174.93
ENSG00000213281	NRAS	0.017133481	0.187	2712.41	3088.26
ENSG00000180139	ACTA2-AS1	0.017957069	-2.238	20.61	3.69
ENSG00000175137	SH3BP5L	0.01801007	-0.317	1764.13	1415.60
ENSG00000165312	OTUD1	0.019358314	0.527	848.06	1222.22
ENSG00000103152	MPG	0.019366431	-0.192	3398.02	2973.81
ENSG00000167562	ZNF701	0.01996541	0.421	297.52	398.60
ENSG00000264278	ZNF236-DT	0.019983655	-1.212	53.51	22.61
ENSG00000116688	MFN2	0.020513769	-0.158	4441.44	3979.25

Gene id	Symbol	FDR	logPostFC	Control mean count	MMW mean count
ENSG00000182107	TMEM30B	0.021067236	0.550	213.02	312.29
ENSG00000126804	ZBTB1	0.021341458	0.155	2515.25	2799.73
ENSG00000113300	CNOT6	0.021937628	0.293	991.94	1215.67
ENSG00000166582	CENPV	0.023664961	-1.464	49.22	17.29
ENSG00000100307	CBX7	0.02376915	0.373	481.65	624.16
ENSG00000174996	KLC2	0.024131754	-0.302	890.24	722.08
ENSG00000137449	CPEB2	0.024853982	0.366	1111.62	1432.43
ENSG00000160055	TMEM234	0.025060365	-0.432	442.64	327.93
ENSG00000115652	UXS1	0.025301218	0.233	1008.19	1185.28
ENSG00000283959		0.026483615	-1.582	34.51	10.95
ENSG00000102910	LONP2	0.027611647	-0.124	4459.44	4093.47
ENSG00000107036	RIC1	0.027845028	0.242	2612.79	3089.63
ENSG00000245552		0.028128226	-2.191	27.03	5.25
ENSG00000110218	PANX1	0.028761825	0.291	1983.32	2426.44
ENSG00000146950	SHROOM2	0.029497132	3.525	0.48	14.62
ENSG00000103657	HERC1	0.029738767	0.140	4943.43	5448.32
ENSG00000049323	LTBP1	0.029825125	-0.329	8893.86	7079.77
ENSG00000111602	TIMELESS	0.029840819	-0.565	603.43	407.55
ENSG00000155592	ZKSCAN2	0.030260933	0.341	445.19	564.03
ENSG00000171862	PTEN	0.030660734	0.128	5616.42	6139.26
ENSG00000166508	MCM7	0.031103586	-0.437	2411.41	1780.56
ENSG00000172890	NADSYN1	0.031391718	-0.186	2473.40	2174.45
ENSG00000064651	SLC12A2	0.032079898	0.228	1477.97	1731.02
ENSG00000224420	ADM5	0.033340859	3.511	0.46	14.23
ENSG00000287126		0.034006525	1.215	20.78	49.40
ENSG00000135624	CCT7	0.035816354	-0.103	6102.40	5681.49
ENSG00000175066	GK5	0.036396889	0.263	759.36	911.58
ENSG00000101199	ARFGAP1	0.037630973	-0.145	3190.54	2884.46
ENSG00000144452	ABCA12	0.040788307	-1.442	37.05	13.10
ENSG00000122952	ZWINT	0.041263452	-0.827	447.14	251.63
ENSG00000136869	TLR4	0.043161947	0.371	2421.84	3132.79
ENSG00000111665	CDCA3	0.04336622	-0.944	241.00	124.89
ENSG00000272734	ADIRF-AS1	0.044362654	0.655	97.43	153.87
ENSG00000126254	RBM42	0.045467986	-0.215	1408.83	1213.89
ENSG00000123870	ZNF137P	0.047885986	-1.205	49.63	21.04
ENSG00000187741	FANCA	0.049002734	-0.744	224.21	133.48