ALLEN INSTITUTE for BRAIN SCIENCE
Fueling Discovery

TECHNICAL WHITE PAPER:
TOP 1,000 GENES ANALYSIS

As a validation of the *in situ* hybridization adult mouse data in the Allen Brain Atlas, an analysis of the 1,000 genes receiving the greatest number of website hits was performed. The highest-ranked 100 of these 1,000 genes were investigated by comparison with peer reviewed literature from scientific journals. The expression patterns of the remaining 900 genes were compared whenever possible to those in two on-line mouse brain gene expression databases, Brain Gene Expression Map (BGEM), and Gene Expression Nervous System Atlas (GENSAT). In addition, the top 1,000 genes were categorized according to standard gene ontology. The data from the gene expression and ontological analyses are presented below.

METHODS

Generation of Top 1,000 Gene List

All 20,000+ genes in the Allen Brain Atlas (ABA) database of gene expression in the adult mouse brain were ranked according to the number of combined hits received in two image viewers available in the mouse brain Web application at www.brain-map.org. Because these viewers are the image tools used to view ABA data, the number of hits for each gene is a measure of how often the gene data is looked at. The 1,000 highest-ranked genes from the ABA for a six month period were selected for this analysis.

Literature Comparison of Top 100 Genes

The 100 highest-ranked genes were chosen for scientific journal literature comparison. Articles found by querying the PubMed database were selected for data comparable to ABA data. Using only articles containing images of mRNA or protein data from adult rat or mouse, expression profiles were compared. Whenever possible, a whole brain comparison was performed. Expression in each coronal and/or sagittal section in the literature was compared structure by structure with expression in matching coronal and/or sagittal sections in the ABA. In other cases, when a whole brain data set was not provided in the literature, hallmark expression within individual structures was compared using textual descriptions of expression as an additional means of comparison.

Database Comparison of Next 900 Genes

The next 900 highest-ranked genes were compared to gene expression data found in two publicly available on-line databases, BGEM and GENSAT. The BGEM database presents darkfield images of mRNA expression across the mouse brain using radioactive riboprobes for in situ hybridization. GENSAT contains gene expression data generated from bacterial artificial chromosome (BAC) transgenic mice, where endogenous protein coding sequences have been replaced with sequences encoding an EGFP reporter gene in each transgenic vector. Because each of these databases uses a different experimental methodology, unique criteria were required for comparisons between their data and that of the ABA.

BGEM

Because its platform is more similar to the colorimetric in situ hybridization platform of the ABA, the BGEM database was the preferred data source for comparisons. Whenever possible, coronal and sagittal sections (maximum of 8 and 3 respectively) of adult data were compared to corresponding ABA coronal and sagittal sections, and corresponding structures were compared. If data in only one plane was provided, it was considered sufficient as a means of comparison. As the BGEM database was the primary data source for the majority of comparisons, if its gene expression data matched that of the ABA this was considered sufficient for validation. However, if a gene was not found in the BGEM database, if BGEM data did not correspond to

ABA data, or if BGEM data were not of sufficient quality to carry out the comparison, then GENSAT was used as an alternative data source.

GENSAT
The GENSAT database supplies gene expression data derived from transgenic mice in the sagittal plane (~13 sections). Because of the greater difference between GENSAT and ABA platforms, more general comparison criteria were required than for BGEM and ABA data. For these comparisons, hallmark features of expression (i.e. cortex laminarity, expression restricted to individual nuclei, expression restricted to a particular cell type, etc.) were observed in both data sets and compared. If these hallmark features of expression matched across the brain, the match was considered sufficient for validation. If ABA data disagreed with GENSAT data, peer reviewed literature sources were then utilized for comparisons.

Literature
For the remaining 900 genes, peer reviewed literature was referred to only in the cases where BGEM and/or GENSAT adult data were available and did not corroborate ABA data. The literature comparisons for these genes were equivalent to those carried out for the top 100 genes. A literature match was considered validation of ABA data, despite mismatching BGEM and/or GENSAT data.

Analysis of Gene Ontology
The top 1,000 genes were additionally subjected to a gene ontology analysis using PANTHER (Protein Analysis Through Evolutionary Relationships). PANTHER is a classification system that uses evolutionary relationships combined with published experimental evidence to classify genes by function. Thus, by providing a categorical analysis of the top 1,000 genes in the ABA, PANTHER offers a measure of interest in each gene family for the scientific community using the ABA. The top 10 molecular function categories for the 1,000 genes are presented in Figure 1. A sub-family analysis was carried out on the top two of these categories, ion channels and G protein-coupled receptors (Figures 2 and 3). The GPCR analysis was carried out using the KEGG GPCR ligand list.

RESULTS

Top 100 Genes
A comparison between peer reviewed literature and ABA data for the top 100 genes yielded the following results: 92/95 analyzable genes showed matching expression profiles (97% of genes compared), with 3/95 mismatches. Two ABA genes were being processed for issues of data quality at the time of writing this report and could not be compared (These genes appear as N/A in Table 2). Additionally, for three genes, sufficient data could not be found in the literature or in either on-line database (BGEM or GENSAT) to carry out a comparison.

Literature Mismatches
In the three cases of mismatch, expression data provided in the literature was significantly different than ABA data, either across the brain or in structures featuring hallmark expression. In these cases, an attempt was made to find an additional literature data source in order to confirm expression characteristics. In the cases where ABA data remains uncorroborated, ABA probes are under further investigation, and data is currently being re-processed.

Next 900 Genes
Of the remaining 900 genes, 391 were found in either or both of the on-line databases. Of these 391 genes, 362 showed gene expression profiles matching ABA data (94% of all compared genes), 25 exhibited mismatching profiles, 4 were in process at the writing of this report, and 509 were not found in either of the two on-line databases (Table 1). Note: For the 509 genes not contained in either of the on-line databases, validation comparisons were not performed.

Table 1: Summary of top 1,000 genes analysis

Top 100 genes	
Matches	92
Mismatches	3
In process	2
Not found in literature	3
Next 900 genes	
Matches	362
Mismatches	25
In process	4
Not found in BGEM or GENSAT	509

Mismatches

As stated previously, if BGEM data were not found or did not match ABA data, GENSAT was consulted. Subsequently, if GENSAT data were not found or did not match ABA data, then peer reviewed literature sources were consulted (Note: Literature was only consulted in cases where data was found in at least one of the databases). A mismatch occurred when ABA data were found in any or all of these sources but not corroborated.

BGEM mismatches – In 19 of 25 cases, BGEM data did not match ABA data and could not be validated by GENSAT or literature sources. One possibility for discrepancies between ABA and BGEM data in general is the difference in experimental methodologies. BGEM uses radioactive probes for in situ hybridization and presents data as darkfield images. The ABA uses colorimetric probes and presents data as brightfield images. These experimental differences sometimes make the data sets difficult to compare, especially when expression is at very low levels. In addition, the difference in sampling frequencies makes gene expression in some structures very difficult to compare accurately.

GENSAT mismatches – In 9 of the mismatch cases, GENSAT data did not agree with ABA data and could not be validated using BGEM or literature sources. As with BGEM, platform differences may account for discrepancies seen between ABA and GENSAT data. Because the methodology used by GENSAT does not directly measure mRNA abundance, fine-scale comparisons of GENSAT and ABA in situ hybridization data are particularly difficult. Differences in sampling frequency and the absence of coronal GENSAT data further complicate comparisons between data sets.

Literature mismatches – ABA data disagreed with literature data in 5 of the mismatch cases. Again, depending on the platform used in each case, differences in experimental methodology could be an obstacle to comparison. However, because these data were found in peer reviewed literature and because they were selected for comparability, disagreements between literature and ABA data were considered particularly reliable. In these cases, ABA probes are under investigation to ensure data accuracy. Note: In all 25 cases of mismatched data, ABA data are either being reprocessed or are under investigation for probe discrepancy. A detailed list of all genes with comparison data is provided in Table 2.

Gene Ontology

The top 1,000 genes were analyzed by PANTHER and categorized by molecular function. According to this analysis, two categories in particular contained a substantially greater number of genes than any other category, ion channels and G-protein coupled receptors (97 and 94 genes respectively). The top 10 molecular function categories are presented in Figure 1. These top two categories were subsequently selected for additional analysis by molecular function sub-family. The results of this analysis are presented in Figures 2 and 3.

Figure 1: Summary of top 10 molecular function categories

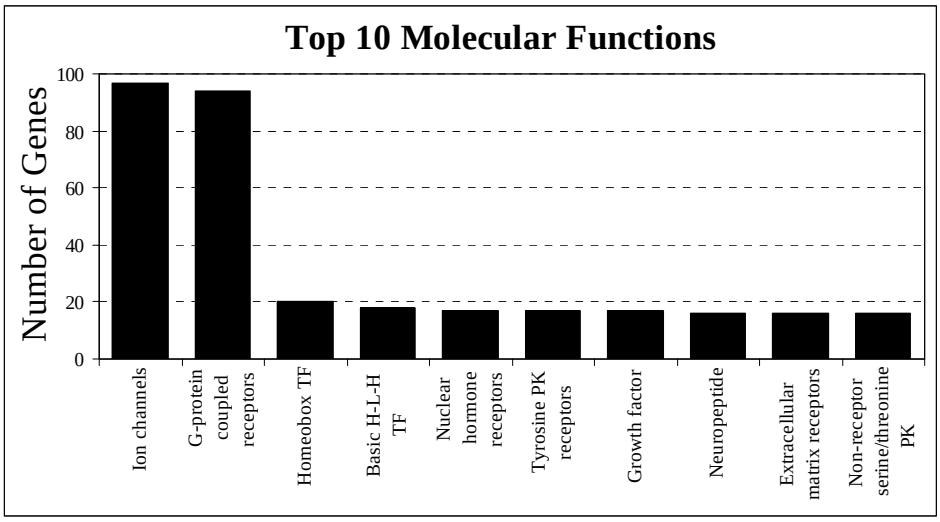


Figure 2: Summary of molecular function ion channel sub-family categories

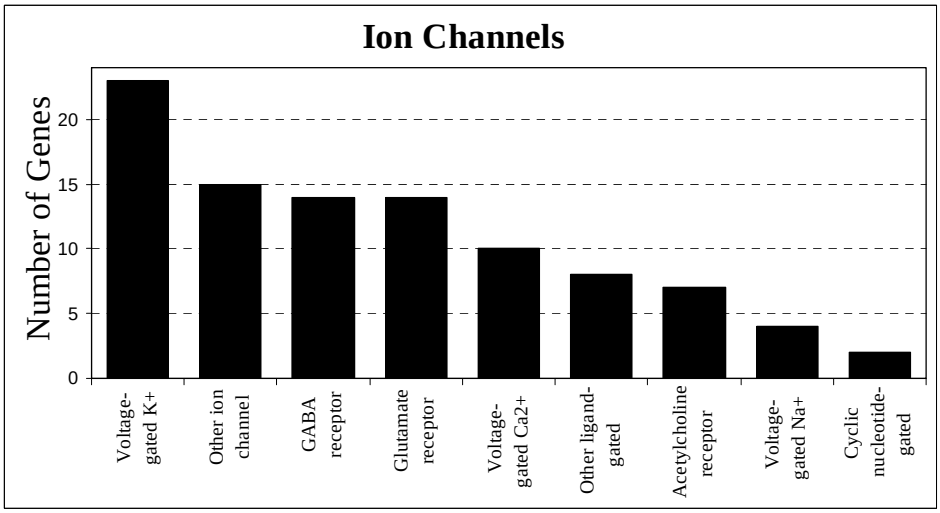
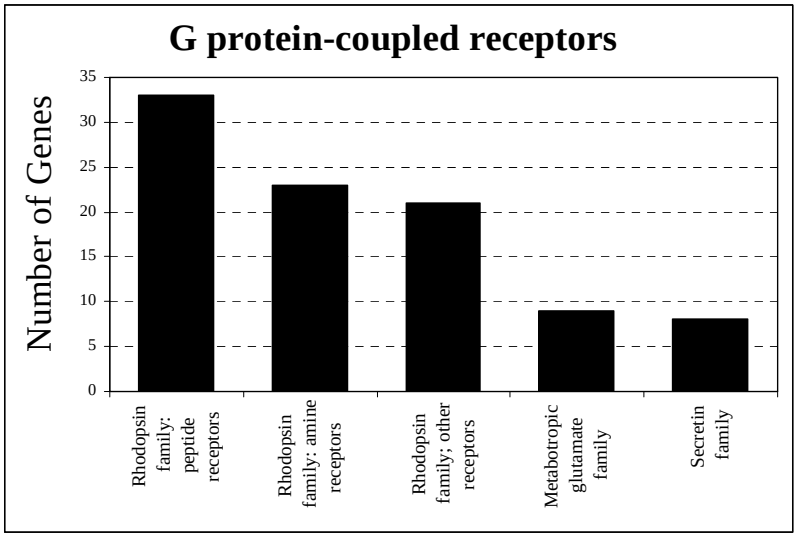


Figure 3: Summary of molecular function GPCR sub-family categories



SUMMARY

This analysis of the top 1,000 genes in the ABA illustrates that the vast majority of gene expression data presented is similar to that of other public datasets and with peer reviewed literature. We were able to directly compare 486 genes, and of these 454 (94%) were in general agreement with other sources. While not a comprehensive analysis of the more than 20,000 genes in the ABA, this representative sub-sampling of the genes of greatest interest to the Neuroscience community provides important validation of the scientific accuracy of the ABA dataset. In the small number of genes (28) where data was mismatching or not comparable, discrepancies are being investigated on a case-by-case basis for data improvement.

The PANTHER analysis provides a valuable assessment of the ontological categorization of the entire1,000 gene dataset. It is not surprising that ion channel and G protein-coupled receptor families contain the greatest number of genes, as these represent two of the most extensively studied molecular families. The breakdown of these genes into their sub-families offers a more specific evaluation of some genes of greatest interest to the ABA user community.

Table 2: A detailed list of all genes for which a comparison was possible and the results of those comparisons. Genes are listed in order of highest to lowest website hit rank for a six month period. Literature references refer to the bibliography presented at the end of the report.

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Th	21823	135	Yes		
Bdnf	12064	43	Yes		
Gad1	14415	30	Yes		
Camk2a	12322	94	Yes		
Gfap	14580	78	Yes		
Htr2c	15560	133	Yes		
Cnr1	12801	85	Yes		
Drd2	13489	16	Yes		
Slc17a6	140919	42	Yes		
Tph2	216343	21	Yes		
Pvalb	19293	108	Yes		
Calb1	12307	32	Yes		
Npy	109648	36	Yes		
Drd1a	13488	72	Yes		
Nos1	18125	37	Yes		
Lepr	16847	46	Yes		
Crh	12918	18	Yes		
Arc	11838	24	Yes		
Htr1a	15550	14	Yes		
Wfs1	22393	119	Yes		
Nes	18008		N/A		
Calb2	12308	102	Yes		
Penk1	18619	139	Yes		
Avp	11998	13	Yes		
Grin1	14810	98	Yes		
Slc17a7	72961	23	Yes		
Nts	67405	49	Yes		
Trh	22044	81	Yes		
Mbp	17196	38	Yes		
Rxfp3	239336	117	Yes		
Chat	12647	60	Yes		
Dbh	13166	20	Yes		
Gal	14419	19	Yes		

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Foxp2	114142	29	Yes		
Lgr7	381489	99	Yes		
Grm1	14816	109	Yes		
Pomc1	18976	35	Yes		
Slc6a4	15567	4	Yes		
Ngfr	18053	100	Yes		
Shh	20423	122	Yes		
Gad2	14417	28	No		
Dcx	13193	136	Yes		
Grm5	108071	104	Yes		
Pcp4	18546	11	Yes		
Sst	20604	141	Yes		
Prkcd	18753	34	Yes		
Chrna7	11441	131	Yes		
Reln	19699	48	Yes		
Cck	12424	141	Yes		
Gria1	14799	77	Yes		
Fos	14281		Not found	Yes	
Avpr1a	54140	95	Yes		
Cart	27220	56	Yes		
Grin2b	14812	130	Yes		
Ache	11423	44	Yes		
Pdyn	18610	65	Yes		
Gabra6	14399	55	Yes		
Gpr161	240888		Not found	Not found	Not found
Pax6	18508	115	Yes		
Slc6a3	13162	110	Yes		
Snca	20617	9	Yes		
Dlk1	13386	50	Yes		
Ntrk2	18212	142	No		
Slc1a2	20511	107	Yes		
Drd3	13490	26	Yes		
Sox2	20674	6	Yes		
Gabrd	14403	132	No		
Adra2a	11551	93	Yes		
Mef2c	17260	70	Yes		
Dlx1	13390	105	Yes		
Crhr1	12921	124	Yes		
Etv1	14009	137	Yes		
Neurod1	18012	90	Yes		
Egr1	13653	54	Yes		
Tac1	21333	129	Yes		
App	11820	52	Yes		
Mecp2	17257		N/A		
Slc17a8	216227	40	Yes		
Aqp4	11829	91	Yes		
Ngfb	18049	59	Yes		
Oxt	18429	13	Yes		
Hcrt	15171	118	Yes		
Scn4b	399548	138	Yes		
Gria2	14800	8	Yes		
Prom1	19126		Not found	Not found	Yes
Chrm2	243764	126	Yes		
Prox1	19130	61	Yes		

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Gpr101	245424	2	Yes		
Dkk3	50781	57	Yes		
Xpnpep2	170745	27	Yes		
Oprm1	18390	71	Yes		
Ascl1	17172	97	Yes		
Calca	12310	121	Yes		
Tcf7l2	21416		Not found	Not found	Not found
Catnb	12387		Not found	Not found	Not found
Gabrg1	14405	101	Yes		
Kcnk2	16526	120	Yes		
Gja9	14617	3	Yes		
Gpr88	64378	84	Yes		
Ar	11835	113	Yes		
Ntn1	18208	66	Yes		
Drd4	13491		N/A	N/A	N/A
Adcyap1	11516			Yes	
Sparc	20692	79	Yes	No	Not found
Cacna1g	12291			Yes	
Wnt5a	22418			Yes	
Zfp312	54713			Not found	Yes
Gja1	14609			Yes	
Nnat	18111			Not found	Yes
Nrg1	211323	17	Yes	No	Not found
Htr3a	15561			Yes	
Sema3a	20346			Yes	
Per2	18627			Not found	Yes
Igfbp4	16010			Yes	
Npy1r	18166			Yes	
Ntrk1	18211			Yes	
Atp1a2	98660			Yes	
Cckbr	12426			Yes	
Chrm1	12669			Yes	
Kcnd2	16508			Yes	
Hdac6	15185			Yes	
Esr2	13983	112	Yes	No	No
Slc6a2	20538			Yes	
Efna5	13640	140	Yes	No	Not found
Gpr37	14763	73	Yes	Not found	No
Cbln3	56410			Yes	
Tubb3	22152	80	Yes	Not found	No
Chrm3	12671			Yes	
Nr4a2	18227			Yes	
Crlf1	12931			Yes	
Adcy2	210044			Yes	
Nefh	380684			Yes	
Crym	12971			Yes	
Trpc6	22068			Yes	
Olig2	50913			No	Yes
Gap43	14432			Yes	
Trhr	22045	12	Yes	Not found	No
Oxtr	18430	123	Yes	Not found	No
Sema3e	20349			Yes	
Ghsr	208188	143	Yes	No	Not found
Ddc	13195			Not found	Yes

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Rorb	225998			Yes	
Stx1a	20907			Yes	
Zic1	22771			Not found	Yes
Cdh2	12558			Yes	
Hes1	15205	116	No	Not found	No
Slc2a1	20525			Yes	
Notch1	18128			Yes	
Kcnc1	16502			Yes	
Epha4	13838	87	Yes	Not found	No
Pcp2	18545			Yes	
Hap1	15114			Not found	Yes
Grp	225642			Yes	
Gfra1	14585			Yes	
Odz3	23965			Yes	
Hdc	15186			Yes	
Phox2b	18935			Yes	
Htr2b	15559			Yes	
Slit1	20562	74	Yes	Not found	No
Id4	15904	53	Yes	No	No
Isl1	16392			Yes	
Sepp1	20363			Yes	
Htr1b	15551	75	Yes	Not found	No
Fmr1	14265	41	Yes	No	No
Ntsr1	18216			Yes	
Zbtb20	56490			Yes	
Ntf3	18205			Yes	
Tiam1	21844			Yes	
Grm2	108068			Not found	Yes
Neurod6	11922	1	Yes	Not found	No
Tcf4	21413			Yes	
Mc4r	17202			Yes	
S100a10	20194			Yes	
Grm4	268934			Yes	
Mapt	17762			Yes	
Gpr83	14608			Yes	
Wnt7b	22422		Not found	No	Not found
Lrp2	14725			Yes	
Cxcl12	20315		Not found	No	No
Dock10	210293			Yes	
Neurog2	11924	96	Yes	Not found	No
Ncam1	17967			Yes	
Slc18a2	214084			No	Yes
Tieg1	21847	134	Yes	Not found	No
Ttr	22139			Yes	
Sepm	114679		Not found	No	Not found
Sox10	20665			Yes	
Rgs5	19737			Yes	
Ntng2	171171			Yes	
Ucn3	83428			Not found	Yes
Htr2a	15558		N/A	N/A	N/A
Grin2c	14813	130	Yes	Not found	No
Ecel1	13599			Yes	
Nov	18133			Yes	
Dlx2	13392			Not found	Yes

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Cbln2	12405			Yes	
Emx2	13797			Yes	
Met	17295			Not found	Yes
Cnr2	12802			Yes	
Slc12a5	57138	51	Yes	Not found	No
Aldoc	11676			Yes	
Aldh1a1	11668			Yes	
Gprc5b	64297			Yes	
Galr1	14427	39	No	No	Not found
Kcnq3	110862			Yes	
Pten	19211			Yes	
Asb4	65255	63	Yes	No	Not found
Slc6a1	232333			Yes	
Ppfibp1	67533		Not found	No	Not found
Gpr74	104443			Yes	
Gpr139	209776			Not found	Yes
Emp1	13730			Not found	Yes
Scg2	20254			Yes	
Grn	14824	22	Yes	No	Not found
Tbr1	21375			Yes	
Frzb	20378			Yes	
Ppp1r1b	19049			Not found	Yes
Trpv4	63873			Yes	
L1cam	16728			Yes	
Pbx3	18516			Yes	
Edg2	14745			Yes	
Satb2	212712			Not found	Yes
Gabbr1	54393	69	Yes	Not found	No
Syt1	20979	76	Yes	No	Not found
Itpr1	16438			Yes	
Egfr	13649	31	Yes	No	Not found
Kitl	17311			Yes	
Mdk	17242			Not found	Yes
Tnf	24835			Yes	
Gpr6	140741			Yes	
Prkcz	18762			Yes	
Nmb	68039	127	Yes	No	Not found
Cst3	13010			Yes	
Lypd1	72585			Yes	
Tac2	21334			Yes	
Agt	11606			Yes	
Gpr54	114229			Yes	
Gpr51	242425			Yes	
Gabrg2	14406			Yes	
Syt9	60510			Yes	
Cacna2d1	12293			Yes	
Slc31a1	20529			Yes	
Cflar	12633			Yes	
Rora	19883	92	Yes	No	Not found
Nradd	67169			Yes	
Unc5d	210801		Not found	No	Not found
Gabrb3	14402			Yes	
Srr	27364			Yes	
Cdk4	12567		Not found	Not found	No

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Rgs9	19739			Yes	
Avpr2	12000			Yes	
Eef1a1	13627			Yes	
Chrna4	11438			Yes	
Gng13	64337			Yes	
A930038C07Rik	68169			Not found	Yes
Sox9	20682			Yes	
Cklfsf5	67272			Yes	
Arpp21	74100			Yes	
Lypd1	72585			Yes	
Lrrn1	16979			Yes	
Ncoa1	17977			Yes	
Lhx2	16870		Not found	No	Not found
Sepw1	20364			Yes	
Tcfe2a	21423			No	Yes
Gdf11	14561			Not found	Yes
Nr2f2	11819	68	Yes	Not found	No
6430514L14Rik	76886			Not found	Yes
Bcl6	12053			Yes	
Lgi3	213469			Yes	
Epha7	13841			Yes	
Glul	14645	64	Yes	No	Not found
Mtap1b	17755			Yes	
Sstr4	20608			Not found	Yes
Titf1	21869		Not found	Not found	No
Capns1	12336			Yes	
Ntrk3	18213			Yes	
Grm3	108069			Yes	
Chrm4	12672	62	Yes	Not found	No
Nrn1	68404			Yes	
Rgs10	67865			Yes	
Pnoc	18155			Not found	Yes
Uchl1	22223	82	Yes	Not found	No
Syt5	53420			Yes	
Slc6a5	104245			Yes	
Cacng7	81904			Yes	
Galr2	14428			Yes	
Tiam2	24001			Yes	
Tlx3	27140		Not found	Not found	No
Vim	22352			Yes	
Ube3a	22215		N/A	N/A	N/A
Cntn2	21367			Not found	Yes
Popdc3	78977			Yes	
Efnb2	13642			Yes	
Grid2ip	170935	83	Yes	Not found	No
Nf1	18015			Yes	
Pdgfra	18595			Yes	
Camk2d	108058			Yes	
Nefl	18039			Yes	
Htr4	15562			Yes	
Drpla	13498			Yes	
Nrp1	18186			Yes	
Nlgn3	245537			Yes	
Ankrd38	242553			Yes	

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Bzrp	12257			Yes	
Bmp7	12162			Not found	Yes
Dhcr24	74754			Yes	
Camkk2	207565	106	Yes	Not found	No
Gabrb2	14401	67	Yes	Not found	No
Sema3f	20350			Yes	
Sirt1	93759			Yes	
Tpd52l1	21987			Yes	
Nova1	18134			Yes	
Cdh1	12550			Yes	
C920006C10Rik	76740		Not found	Not found	No
Adra2b	11552	128	Yes	No	Not found
Rgs8	67792			Yes	
Gbas	14467			Yes	
Chrna5	110835			Yes	
Rgs16	19734			Yes	
Plxna2	18845			Yes	
Cdkn1b	12576			Yes	
Col6a1	12833			Yes	
Mlf1	17349		Not found	No	Not found
Prkca	18750			Yes	
Sema7a	20361			Not found	Yes
Igf1	16000			Yes	
Hpcal4	170638			Yes	
Ltb4r1	16995			Yes	
Sstr5	20609			Yes	
Fxr1h	14359		Not found	No	Not found
Axot	57438		Not found	No	Not found
Elmo1	140580			Yes	
Kit	16590			Yes	
6430573F11Rik	319582			Yes	
Gabt4	243616			Yes	
Gapd	407972			Yes	
Nmyc1	12759	89	Yes	Not found	No
Clu	12759			Yes	
Grin2d	14814			Yes	
Cdkn1a	12575			Yes	
Igf1r	16001			Yes	
Gpr56	14766			Not found	Yes
Fxyd6	59095			Yes	
Apod	11815			Yes	
Nedd4	17999			Yes	
Vegfa	22339			Yes	
Pik3r1	18708	45	Yes	Not found	No
Glrb	14658			Yes	
Nsdhl	18194			Yes	
Insr	16337			Yes	
Actg1	11465			Yes	
Fgf13	14168	114	Yes	Not found	No
Pitx2	18741			Yes	
Grin3b	170483			Yes	
Mchr1	207911			Yes	
Chrna6	11440			Not found	Yes
Slitrk6	239250			Yes	

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Nucb2	53322			Yes	
Bcl2l11	12125			Yes	
Rest	228550		N/A	N/A	N/A
Itpka	19712			Yes	
Dfy	13349			Yes	
Camk4	12326			Yes	
Maged1	94275			Yes	
Styk1	243659			Yes	
Hnt	235106			Yes	
Rgs4	19736			Not found	Yes
Fgf15	14170		Not found	Not found	No
Nrp2	18187	33	No	No	No
Npy2r	18167			Yes	
Drd5	13492			Yes	
Homer1	26556			Not found	Yes
Lmna	16905			Yes	
Mtap	66902			Not found	Yes
Kcnip1	70357			Yes	
Kcnj2	16518	88	Yes	No	Not found
Sema6a	20358			Yes	
AI427515	270097			Yes	
Stat1	20846			Yes	
Chrm5	213788	125	Yes	Not found	No
Ppp1r14a	68458			Yes	
Adra2c	11553			Yes	
Dcn	13179			Yes	
Notch3	18131			Not found	Yes
Nhlh1	18071			Yes	
Ceacam10	26366		Not found	No	Not found
Slc29a1	63959			Yes	
Chrna3	110834			Yes	
Dedd	21945		Not found	No	Not found
Kcnc2	268345			Yes	
Cldn5	12741			Yes	
Homer2	26557			Yes	
Thra	21833			Yes	
Alk	11682			Yes	
P2rx7	17984		Not found	No	No
Ndn	18439			Yes	
Slc1a1	20510			Yes	
Ptger3	19218			Yes	
Gpr44	14764			Yes	
Acvrl1	11482			Yes	
Bmp4	12159			Yes	
Htr1d	15552	10	Yes	No	No
Kif5a	16572			Yes	
Bmp3	110075			Yes	
Dyrk1a	13548			Yes	
Gpr37l1	171469			Yes	
Bnip3	12176			Yes	
Chl1	12661			Yes	
Fyn	14360			Yes	
Serpini1	20713			Yes	
Cyp4v3	102294			Yes	

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Arl7	320982			Yes	
Fgfr1	14182			Yes	
Rapgef4	56508			Yes	
Trps1	83925			Yes	
Lgi2	55203			Yes	
Syt2	20980	5	Yes	No	Not found
Sstr2	20606	7	Yes	Not found	No
Spp1	20750	111	Yes	Not found	No
Ednrb	13618			Yes	
Apoe	11816			Yes	
Ghrh	14601			Yes	
Shank3	58234			Yes	
Arhgdib	11857			Yes	
Plcb1	18795			Yes	
P2ry1	18441	86	No	No	Not found
Ckb	12709			Yes	
Lhx1	16869			Yes	
Tgfb2	21808			Yes	
Ranbp9	56705		Not found	No	Not found
Wwc1	211652		Not found	No	Not found
Lgals1	16852			Yes	
Foxp1	108655			Yes	
Gpr73l1	246313			Yes	
Enpp2	18606			Yes	
Gpr12	14738	47	Yes	No	Not found
3110035E14Rik	76982			Yes	
Cdh4	12561			Yes	
Etv5	104156			Yes	
Spata13	219140			Yes	
Abcd2	26874			Yes	
Cyp26b1	232174			Yes	
Plxnd1	67784			Not found	Yes
Opn3	13603			Yes	
Lrrtm1	74342			Yes	
Camk1g	215303			Yes	
Pde7b	29863	103	Yes	No	Not found
Cyp7b1	13123			Yes	
Otof	83762			Not found	Yes
Gpr26	233919			Yes	
Peg10	170676			Yes	
6330527O06Rik	76161			Yes	
Chgb	12653			Yes	
Wif1	24117			Yes	
Adora2a	11540			Yes	
Clock	12753			Yes	
Gpr151	240239			Yes	
Actb	11461			Yes	
Cdh11	12552			Not found	Yes
Hcn2	15166			Not found	Yes
Dusp6	67603			Yes	
Nr4a1	15370			Yes	
Olfm1	56177			Not found	Yes
Pcdh21	170677			Yes	
Cacng5	140723			Yes	

Gene Symbol	NCBI Entrez Gene ID	Literature Reference	Matches Literature?	Matches BGEM?	Matches GENSAT?
Agtr1	11607			Yes	
Fgf1	14164			Yes	
Igfbp5	16011			Yes	
Cbln4	228942			Yes	
Tnfrsf1a	21937			Yes	
Maob	109731			Yes	
Dtnbp1	94245	58	Yes	No	Not found
Nr2f1	13865	68	Yes	No	Not found
Gpr50	14765			Yes	
Smoc2	64074			Yes	
Gsbs	19051	25	Yes	Not found	No
Hrh1	15465			Yes	
Sim1	20464			Yes	
Dcc	13176			Yes	
Nfil3	18030			Not found	Yes
Crhr2	12922	15	No	No	Not found
Chrnb3	108043			Not found	Yes
Trp53bp1	27223		Not found	No	Not found
Gch1	14528			Yes	
Inhba	16323			Yes	
Rgs20	58175			Yes	
Gsn	227753			Not found	Yes
Sidt1	320007			Yes	
Cldn1	12737			Yes	
Ctgf	14219			Yes	
Dusp14	56405			Yes	

REFERENCES

1 Bartholoma, A. and Nave, K. A., NEX-1: a novel brain-specific helix-loop-helix protein with autoregulation and sustained expression in mature cortical neurons. *Mech Dev* **48** (3), 217 (1994).

2 Bates, B. et al., Characterization of Gpr101 expression and G-protein coupling selectivity. *Brain Res* **1087** (1), 1 (2006).

3 Belluardo, N. et al., Expression of connexin36 in the adult and developing rat brain. *Brain Res* **865** (1), 121 (2000).

4 Bengel, D. et al., Cellular localization and expression of the serotonin transporter in mouse brain. *Brain Res* **778** (2), 338 (1997).

5 Berton, F. et al., Developmental regulation of synaptotagmin I, II, III, and IV mRNAs in the rat CNS. *J Neurosci* **17** (4), 1206 (1997).

6 Brazel, C. Y. et al., Sox2 expression defines a heterogeneous population of neurosphere-forming cells in the adult murine brain. *Aging Cell* **4** (4), 197 (2005).

7 Breder, C. D. et al., Differential expression of somatostatin receptor subtypes in brain. *J Neurosci* **12** (10), 3920 (1992).

8 Brene, S., Messer, C., and Nestler, E. J., Expression of messenger RNAs encoding ionotropic glutamate receptors in rat brain: regulation by haloperidol. *Neuroscience* **84** (3), 813 (1998).

9 Brenz Verca, M. S. et al., Distribution of alpha- and gamma-synucleins in the adult rat brain and their modification by high-dose cocaine treatment. *Eur J Neurosci* **18** (7), 1923 (2003).

10 Bruinvels, A. T. et al., Localization of 5-HT1B, 5-HT1D alpha, 5-HT1E and 5-HT1F receptor messenger RNA in rodent and primate brain. *Neuropharmacology* **33** (3-4), 367 (1994).

11 Bulfone, A. et al., Pcp4l1, a novel gene encoding a Pcp4-like polypeptide, is expressed in specific domains of the developing brain. *Gene Expr Patterns* **4** (3), 297 (2004).

12 Calza, L. et al., Distribution of thyrotropin-releasing hormone receptor messenger RNA in the rat brain: an in situ hybridization study. *Neuroscience* **51** (4), 891 (1992).

13 Castel, M. and Morris, J. F., The neurophysin-containing innervation of the forebrain of the mouse. *Neuroscience* **24** (3), 937 (1988).

14 Chalmers, D. T. and Watson, S. J., Comparative anatomical distribution of 5-HT1A receptor mRNA and 5-HT1A binding in rat brain--a combined in situ hybridisation/in vitro receptor autoradiographic study. *Brain Res* **561** (1), 51 (1991).

15 Chen, A. et al., Mouse corticotropin-releasing factor receptor type 2alpha gene: isolation, distribution, pharmacological characterization and regulation by stress and glucocorticoids. *Mol Endocrinol* **19** (2), 441 (2005).

16 Chen, J. F. et al., Neuronal localization and modulation of the D2 dopamine receptor mRNA in brain of normal mice and mice lesioned with 6-hydroxydopamine. *Neuropharmacology* **30** (9), 927 (1991).

17 Chen, M. S. et al., Expression of multiple neuregulin transcripts in postnatal rat brains. *J Comp Neurol* **349** (3), 389 (1994).

18 Chen, Y. et al., Immunocytochemical distribution of corticotropin-releasing hormone receptor type-1 (CRF(1))-like immunoreactivity in the mouse brain: light microscopy analysis using an antibody directed against the C-terminus. *J Comp Neurol* **420** (3), 305 (2000).

19 Cheung, C. C., Hohmann, J. G., Clifton, D. K., and Steiner, R. A., Distribution of galanin messenger RNA-expressing cells in murine brain and their regulation by leptin in regions of the hypothalamus. *Neuroscience* **103** (2), 423 (2001).

20 Cimarusti, D. L. et al., Immunocytochemical localization of dopamine-beta-hydroxylase in rat locus coeruleus and hypothalamus. *Brain Res* **162** (1), 55 (1979).

21 Clark, M. S., McDevitt, R. A., and Neumaier, J. F., Quantitative mapping of tryptophan hydroxylase-2, 5-HT1A, 5-HT1B, and serotonin transporter expression across the anteroposterior axis of the rat dorsal and median raphe nuclei. *J Comp Neurol* **498** (5), 611 (2006).

22 Daniel, R. et al., Cellular localization of gene expression for progranulin. *J Histochem Cytochem* **48** (7), 999 (2000).

23 Danik, M. et al., Frequent coexpression of the vesicular glutamate transporter 1 and 2 genes, as well as coexpression with genes for choline acetyltransferase or glutamic acid decarboxylase in neurons of rat brain. *J Neurosci Res* **81** (4), 506 (2005).

24 de Foubert, G., O'Neill, M. J., and Zetterstrom, T. S., Acute onset by 5-HT(6)-receptor activation on rat brain brain-derived neurotrophic factor and activity-regulated cytoskeletal-associated protein mRNA expression. *Neuroscience* **147** (3), 778 (2007).

25 Detre, J. A., Nairn, A. C., Aswad, D. W., and Greengard, P., Localization in mammalian brain of G-substrate, a specific substrate for guanosine 3',5'-cyclic monophosphate-dependent protein kinase. *J Neurosci* **4** (11), 2843 (1984).

26 Diaz, J. et al., Phenotypical characterization of neurons expressing the dopamine D3 receptor in the rat brain. *Neuroscience* **65** (3), 731 (1995).

27 Ersahin, C., Szpaderska, A. M., and Simmons, W. H., Rat and mouse membrane aminopeptidase P: structure analysis and tissue distribution. *Arch Biochem Biophys* **417** (2), 131 (2003).

28 Esclapez, M. et al., Comparative localization of two forms of glutamic acid decarboxylase and their mRNAs in rat brain supports the concept of functional differences between the forms. *J Neurosci* **14** (3 Pt 2), 1834 (1994).

29 Ferland, R. J. et al., Characterization of Foxp2 and Foxp1 mRNA and protein in the developing and mature brain. *J Comp Neurol* **460** (2), 266 (2003).

30 Ferraguti, F. et al., Distribution of glutamic acid decarboxylase messenger RNA-containing nerve cell populations of the male rat brain. *J Chem Neuroanat* **3** (5), 377 (1990).

31 Fox, I. J. and Kornblum, H. I., Developmental profile of ErbB receptors in murine central nervous system: implications for functional interactions. *J Neurosci Res* **79** (5), 584 (2005).

32 Frantz, G. D. and Tobin, A. J., Cellular distribution of calbindin D28K mRNAs in the adult mouse brain. *J Neurosci Res* **37** (3), 287 (1994).

33 Fujita, H. et al., Expressions of neuropilin-1, neuropilin-2 and semaphorin 3A mRNA in the rat brain after middle cerebral artery occlusion. *Brain Res* **914** (1-2), 1 (2001).

34 Garcia, M. M., Cusick, C. G., and Harlan, R. E., Protein kinase C-delta in rat brain: association with sensory neuronal hierarchies. *J Comp Neurol* **331** (3), 375 (1993).

35 Gee, C. E. et al., Identification of proopiomelanocortin neurones in rat hypothalamus by in situ cDNA-mRNA hybridization. *Nature* **306** (5941), 374 (1983).

36 Gehlert, D. R., Chronwall, B. M., Schafer, M. P., and O'Donohue, T. L., Localization of neuropeptide Y messenger ribonucleic acid in rat and mouse brain by in situ hybridization. *Synapse* **1** (1), 25 (1987).

37 Gotti, S., Sica, M., Viglietti-Panzica, C., and Panzica, G., Distribution of nitric oxide synthase immunoreactivity in the mouse brain. *Microsc Res Tech* **68** (1), 13 (2005).

38 Hartman, B. K., Agrawal, H. C., Kalmbach, S., and Shearer, W. T., A comparative study of the immunohistochemical localization of basic protein to myelin and oligodendrocytes in rat and chicken brain. *J Comp Neurol* **188** (2), 273 (1979).

39 Hawes, J. J. and Picciotto, M. R., Characterization of GalR1, GalR2, and GalR3 immunoreactivity in catecholaminergic nuclei of the mouse brain. *J Comp Neurol* **479** (4), 410 (2004).

40 Herzog, E. et al., Localization of VGLUT3, the vesicular glutamate transporter type 3, in the rat brain. *Neuroscience* **123** (4), 983 (2004).

41 Hinds, H. L. et al., Tissue specific expression of FMR-1 provides evidence for a functional role in fragile X syndrome. *Nat Genet* **3** (1), 36 (1993).

42 Hisano, S. et al., Regional expression of a gene encoding a neuron-specific Na(+)-dependent inorganic phosphate cotransporter (DNPI) in the rat forebrain. *Brain Res Mol Brain Res* **83** (1-2), 34 (2000).

43 Hofer, M. et al., Regional distribution of brain-derived neurotrophic factor mRNA in the adult mouse brain. *EMBO J* **9** (8), 2459 (1990).

44 Hoover, D. B., Muth, E. A., and Jacobowitz, D. M., A mapping of the distribution of acetycholine, choline acetyltransferase and acetylcholinesterase in discrete areas of rat brain. *Brain Res* **153** (2), 295 (1978).

45 Horsch, D. and Kahn, C. R., Region-specific mRNA expression of phosphatidylinositol 3-kinase regulatory isoforms in the central nervous system of C57BL/6J mice. *J Comp Neurol* **415** (1), 105 (1999).

46 Huang, X. F. et al., Localization of leptin receptor mRNA expression in mouse brain. *Neuroreport* **7** (15-17), 2635 (1996).

47 Ignatov, A. et al., Role of the G-protein-coupled receptor GPR12 as high-affinity receptor for sphingosylphosphorylcholine and its expression and function in brain development. *J Neurosci* **23** (3), 907 (2003).

48 Ikeda, Y. and Terashima, T., Expression of reelin, the gene responsible for the reeler mutation, in embryonic development and adulthood in the mouse. *Dev Dyn* **210** (2), 157 (1997).

49 Jennes, L., Stumpf, W. E., and Kalivas, P. W., Neurotensin: topographical distribution in rat brain by immunohistochemistry. *J Comp Neurol* **210** (3), 211 (1982).

50 Jensen, C. H. et al., Neurons in the monoaminergic nuclei of the rat and human central nervous system express FA1/dlk. *Neuroreport* **12** (18), 3959 (2001).

51 Kanaka, C. et al., The differential expression patterns of messenger RNAs encoding K-Cl cotransporters (KCC1,2) and Na-K-2Cl cotransporter (NKCC1) in the rat nervous system. *Neuroscience* **104** (4), 933 (2001).

52 Kawarabayashi, T. et al., Amyloid beta/A4 protein precursor is widely distributed in both the central and peripheral nervous systems of the mouse. *Brain Res* **552** (1), 1 (1991).

53 Kitajima, K., Takahashi, R., and Yokota, Y., Localization of Id2 mRNA in the adult mouse brain. *Brain Res* **1073-1074**, 93 (2006).

54 Knapska, E. and Kaczmarek, L., A gene for neuronal plasticity in the mammalian brain: Zif268/Egr-1/NGFI-A/Krox-24/TIS8/ZENK? *Prog Neurobiol* **74** (4), 183 (2004).

55 Korpi, E. R., Kleingoor, C., Kettenmann, H., and Seeburg, P. H., Benzodiazepine-induced motor impairment linked to point mutation in cerebellar GABAA receptor. *Nature* **361** (6410), 356 (1993).

56 Koylu, E. O., Couceyro, P. R., Lambert, P. D., and Kuhar, M. J., Cocaine- and amphetamine-regulated transcript peptide immunohistochemical localization in the rat brain. *J Comp Neurol* **391** (1), 115 (1998).

57 Krupnik, V. E. et al., Functional and structural diversity of the human Dickkopf gene family. *Gene* **238** (2), 301 (1999).

58 Kumamoto, N. et al., Hyperactivation of midbrain dopaminergic system in schizophrenia could be attributed to the down-regulation of dysbindin. *Biochem Biophys Res Commun* **345** (2), 904 (2006).

59 Lauterborn, J. C., Bizon, J. L., Tran, T. M., and Gall, C. M., NGF mRNA is expressed by GABAergic but not cholinergic neurons in rat basal forebrain. *J Comp Neurol* **360** (3), 454 (1995).

60 Lauterborn, J. C., Isackson, P. J., Montalvo, R., and Gall, C. M., In situ hybridization localization of choline acetyltransferase mRNA in adult rat brain and spinal cord. *Brain Res Mol Brain Res* **17** (1-2), 59 (1993).

61 Lavado, A. and Oliver, G., Prox1 expression patterns in the developing and adult murine brain. *Dev Dyn* **236** (2), 518 (2007).

62 Levey, A. I. et al., Identification and localization of muscarinic acetylcholine receptor proteins in brain with subtype-specific antibodies. *J Neurosci* **11** (10), 3218 (1991).

63 Li, J. Y. et al., Arcuate nucleus transcriptome profiling identifies ankyrin repeat and suppressor of cytokine signalling box-containing protein 4 as a gene regulated by fasting in central nervous system feeding circuits. *J Neuroendocrinol* **17** (6), 394 (2005).

64 Lie-Venema, H., de Boer, P. A., Moorman, A. F., and Lamers, W. H., Role of the 5' enhancer of the glutamine synthetase gene in its organ-specific expression. *Biochem J* **323 (Pt 3)**, 611 (1997).

65 Lin, S. et al., Distribution of prodynorphin mRNA and its interaction with the NPY system in the mouse brain. *Neuropeptides* **40** (2), 115 (2006).

66 Livesey, F. J. and Hunt, S. P., Netrin and netrin receptor expression in the embryonic mammalian nervous system suggests roles in retinal, striatal, nigral, and cerebellar development. *Mol Cell Neurosci* **8** (6), 417 (1997).

67 Lolait, S. J., O'Carroll, A. M., Kusano, K., and Mahan, L. C., Pharmacological characterization and region-specific expression in brain of the beta 2- and beta 3-subunits of the rat GABAA receptor. *FEBS Lett* **258** (1), 17 (1989).

68 Lopes da Silva, S. et al., Localization of transcripts of the related nuclear orphan receptors COUP-TF I and ARP-1 in the adult mouse brain. *Brain Res Mol Brain Res* **30** (1), 131 (1995).

69 Lu, X. Y., Ghasemzadeh, M. B., and Kalivas, P. W., Regional distribution and cellular localization of gamma-aminobutyric acid subtype 1 receptor mRNA in the rat brain. *J Comp Neurol* **407** (2), 166 (1999).

70 Lyons, G. E. et al., Expression of mef2 genes in the mouse central nervous system suggests a role in neuronal maturation. *J Neurosci* **15** (8), 5727 (1995).

71 Mansour, A. et al., Mu, delta, and kappa opioid receptor mRNA expression in the rat CNS: an in situ hybridization study. *J Comp Neurol* **350** (3), 412 (1994).

72 Mansour, A. et al., A comparison of D1 receptor binding and mRNA in rat brain using receptor autoradiographic and in situ hybridization techniques. *Neuroscience* **46** (4), 959 (1992).

73 Marazziti, D. et al., Molecular cloning and chromosomal localization of the mouse Gpr37 gene encoding an orphan G-protein-coupled peptide receptor expressed in brain and testis. *Genomics* **53** (3), 315 (1998).

74 Marillat, V. et al., Spatiotemporal expression patterns of slit and robo genes in the rat brain. *J Comp Neurol* **442** (2), 130 (2002).

75 Maroteaux, L. et al., Mouse 5HT1B serotonin receptor: cloning, functional expression, and localization in motor control centers. *Proc Natl Acad Sci U S A* **89** (7), 3020 (1992).

76 Marqueze, B. et al., Cellular localization of synaptotagmin I, II, and III mRNAs in the central nervous system and pituitary and adrenal glands of the rat. *J Neurosci* **15** (7 Pt 1), 4906 (1995).

77 Martin, L. J. et al., AMPA glutamate receptor subunits are differentially distributed in rat brain. *Neuroscience* **53** (2), 327 (1993).

78 Martin, P. M. and O'Callaghan, J. P., A direct comparison of GFAP immunocytochemistry and GFAP concentration in various regions of ethanol-fixed rat and mouse brain. *J Neurosci Methods* **58** (1-2), 181 (1995).

79 Mendis, D. B. and Brown, I. R., Expression of the gene encoding the extracellular matrix glycoprotein SPARC in the developing and adult mouse brain. *Brain Res Mol Brain Res* **24** (1-4), 11 (1994).

80 Menezes, J. R. and Luskin, M. B., Expression of neuron-specific tubulin defines a novel population in the proliferative layers of the developing telencephalon. *J Neurosci* **14** (9), 5399 (1994).

81 Merchenthaler, I. et al., New data on the immunocytochemical localization of thyrotropin-releasing hormone in the rat central nervous system. *Am J Anat* **181** (4), 359 (1988).

82 Misumi, Y. and Kawano, H., The expressions of epidermal growth factor receptor mRNA and protein gene product 9.5 in developing rat brain. *Brain Res Dev Brain Res* **107** (1), 1 (1998).

83 Miyagi, Y. et al., Delphilin: a novel PDZ and formin homology domain-containing protein that synaptically colocalizes and interacts with glutamate receptor delta 2 subunit. *J Neurosci* **22** (3), 803 (2002).

84 Mizushima, K. et al., A novel G-protein-coupled receptor gene expressed in striatum. *Genomics* **69** (3), 314 (2000).

85 Moldrich, G. and Wenger, T., Localization of the CB1 cannabinoid receptor in the rat brain. An immunohistochemical study. *Peptides* **21** (11), 1735 (2000).

86 Moran-Jimenez, M. J. and Matute, C., Immunohistochemical localization of the P2Y(1) purinergic receptor in neurons and glial cells of the central nervous system. *Brain Res Mol Brain Res* **78** (1-2), 50 (2000).

87 Mori, T. et al., Differential expressions of the eph family of receptor tyrosine kinase genes (sek, elk, eck) in the developing nervous system of the mouse. *Brain Res Mol Brain Res* **29** (2), 325 (1995).

88 Morishige, K. et al., Molecular cloning, functional expression and localization of an inward rectifier potassium channel in the mouse brain. *FEBS Lett* **336** (3), 375 (1993).

89 Mugrauer, G., Alt, F. W., and Ekblom, P., N-myc proto-oncogene expression during organogenesis in the developing mouse as revealed by in situ hybridization. *J Cell Biol* **107** (4), 1325 (1988).

90 Munoz, E. M. et al., NeuroD1: developmental expression and regulated genes in the rodent pineal gland. *J Neurochem* **102** (3), 887 (2007).

91 Nagelhus, E. A., Mathiisen, T. M., and Ottersen, O. P., Aquaporin-4 in the central nervous system: cellular and subcellular distribution and coexpression with KIR4.1. *Neuroscience* **129** (4), 905 (2004).

92 Nakagawa, S., Watanabe, M., and Inoue, Y., Prominent expression of nuclear hormone receptor ROR alpha in Purkinje cells from early development. Neurosci Res 28 (2), 177 (1997).

93 Nicholas, A. P., Pieribone, V., and Hokfelt, T., Distributions of mRNAs for alpha-2 adrenergic receptor subtypes in rat brain: an in situ hybridization study. *J Comp Neurol* **328** (4), 575 (1993).

94 Ochiishi, T., Terashima, T., and Yamauchi, T., Specific distribution of Ca2+/calmodulin-dependent protein kinase II alpha and beta isoforms in some structures of the rat forebrain. *Brain Res* **659** (1-2), 179 (1994).

95 Ostrowski, N. L., Lolait, S. J., and Young, W. S., 3rd, Cellular localization of vasopressin V1a receptor messenger ribonucleic acid in adult male rat brain, pineal, and brain vasculature. *Endocrinology* **135** (4), 1511 (1994).

96 Ozen, I. et al., Proliferating neuronal progenitors in the postnatal hippocampus transiently express the proneural gene Ngn2. *Eur J Neurosci* **25** (9), 2591 (2007).

97 Parras, C. M. et al., Mash1 specifies neurons and oligodendrocytes in the postnatal brain. *EMBO J* **23** (22), 4495 (2004).

98 Petralia, R. S., Yokotani, N., and Wenthold, R. J., Light and electron microscope distribution of the NMDA receptor subunit NMDAR1 in the rat nervous system using a selective anti-peptide antibody. *J Neurosci* **14** (2), 667 (1994).

99 Piccenna, L. et al., Localization of LGR7 gene expression in adult mouse brain using LGR7 knock-out/LacZ knock-in mice: correlation with LGR7 mRNA distribution. *Ann N Y Acad Sci* **1041**, 197 (2005).

100 Pioro, E. P. and Cuello, A. C., Distribution of nerve growth factor receptor-like immunoreactivity in the adult rat central nervous system. Effect of colchicine and correlation with the cholinergic system--I. Forebrain. *Neuroscience* **34** (1), 57 (1990).

101 Pirker, S. et al., GABA(A) receptors: immunocytochemical distribution of 13 subunits in the adult rat brain. *Neuroscience* **101** (4), 815 (2000).

102 Resibois, A. and Rogers, J. H., Calretinin in rat brain: an immunohistochemical study. *Neuroscience* **46** (1), 101 (1992).

103 Reyes-Irisarri, E., Perez-Torres, S., and Mengod, G., Neuronal expression of cAMP-specific phosphodiesterase 7B mRNA in the rat brain. *Neuroscience* **132** (4), 1173 (2005).

104 Romano, C. et al., Distribution of metabotropic glutamate receptor mGluR5 immunoreactivity in rat brain. *J Comp Neurol* **355** (3), 455 (1995).

105 Saino-Saito, S., Berlin, R., and Baker, H., Dlx-1 and Dlx-2 expression in the adult mouse brain: relationship to dopaminergic phenotypic regulation. *J Comp Neurol* **461** (1), 18 (2003).

106 Sakagami, H., Umemiya, M., Saito, S., and Kondo, H., Distinct immunohistochemical localization of two isoforms of Ca2+/calmodulin-dependent protein kinase kinases in the adult rat brain. *Eur J Neurosci* **12** (1), 89 (2000).

107 Schmitt, A. et al., Expression of the glutamate transporter GLT1 in neural cells of the rat central nervous system: non-radioactive in situ hybridization and comparative immunocytochemistry. *Neuroscience* **71** (4), 989 (1996).

108 Seto-Ohshima, A., Emson, P. C., Berchtold, M. W., and Heizmann, C. W., Localization of parvalbumin mRNA in rat brain by in situ hybridization histochemistry. *Exp Brain Res* **75** (3), 653 (1989).

109 Shigemoto, R., Nakanishi, S., and Mizuno, N., Distribution of the mRNA for a metabotropic glutamate receptor (mGluR1) in the central nervous system: an in situ hybridization study in adult and developing rat. *J Comp Neurol* **322** (1), 121 (1992).

110 Shimada, S., Kitayama, S., Walther, D., and Uhl, G., Dopamine transporter mRNA: dense expression in ventral midbrain neurons. *Brain Res Mol Brain Res* **13** (4), 359 (1992).

111 Shin, S. L. et al., Expression of osteopontin mRNA in the adult rat brain. *Neurosci Lett* **273** (2), 73 (1999).

112 Shughrue, P. et al., The distribution of estrogen receptor-beta mRNA in forebrain regions of the estrogen receptor-alpha knockout mouse. *Endocrinology* **138** (12), 5649 (1997).

113 Simerly, R. B., Chang, C., Muramatsu, M., and Swanson, L. W., Distribution of androgen and estrogen receptor mRNA-containing cells in the rat brain: an in situ hybridization study. *J Comp Neurol* **294** (1), 76 (1990).

114 Smallwood, P. M. et al., Fibroblast growth factor (FGF) homologous factors: new members of the FGF family implicated in nervous system development. *Proc Natl Acad Sci U S A* **93** (18), 9850 (1996).

115 Stoykova, A. and Gruss, P., Roles of Pax-genes in developing and adult brain as suggested by expression patterns. *J Neurosci* **14** (3 Pt 2), 1395 (1994).

116 Stump, G. et al., Notch1 and its ligands Delta-like and Jagged are expressed and active in distinct cell populations in the postnatal mouse brain. *Mech Dev* **114** (1-2), 153 (2002).

117 Sutton, S. W. et al., Distribution of G-protein-coupled receptor (GPCR)135 binding sites and receptor mRNA in the rat brain suggests a role for relaxin-3 in neuroendocrine and sensory processing. *Neuroendocrinology* **80** (5), 298 (2004).

118 Swanson, L. W., Sanchez-Watts, G., and Watts, A. G., Comparison of melanin-concentrating hormone and hypocretin/orexin mRNA expression patterns in a new parceling scheme of the lateral hypothalamic zone. *Neurosci Lett* **387** (2), 80 (2005).

119 Takeda, K. et al., WFS1 (Wolfram syndrome 1) gene product: predominant subcellular localization to endoplasmic reticulum in cultured cells and neuronal expression in rat brain. *Hum Mol Genet* **10** (5), 477 (2001).

120 Talley, E. M. et al., Cns distribution of members of the two-pore-domain (KCNK) potassium channel family. *J Neurosci* **21** (19), 7491 (2001).

121 Terrado, J. et al., Expression of the genes for alpha-type and beta-type calcitonin gene-related peptide during postnatal rat brain development. *Neuroscience* **80** (3), 951 (1997).

122 Traiffort, E. et al., Discrete localizations of hedgehog signalling components in the developing and adult rat nervous system. *Eur J Neurosci* **11** (9), 3199 (1999).

123 Vaccari, C., Lolait, S. J., and Ostrowski, N. L., Comparative distribution of vasopressin V1b and oxytocin receptor messenger ribonucleic acids in brain. *Endocrinology* **139** (12), 5015 (1998).

124 Van Pett, K. et al., Distribution of mRNAs encoding CRF receptors in brain and pituitary of rat and mouse. *J Comp Neurol* **428** (2), 191 (2000).

125 Vilaro, M. T., Palacios, J. M., and Mengod, G., Localization of m5 muscarinic receptor mRNA in rat brain examined by in situ hybridization histochemistry. *Neurosci Lett* **114** (2), 154 (1990).

126 Vilaro, M. T., Wiederhold, K. H., Palacios, J. M., and Mengod, G., Muscarinic M2 receptor mRNA expression and receptor binding in cholinergic and non-cholinergic cells in the rat brain: a correlative study using in situ hybridization histochemistry and receptor autoradiography. *Neuroscience* **47** (2), 367 (1992).

127 Wada, E., Way, J., Lebacq-Verheyden, A. M., and Battey, J. F., Neuromedin B and gastrin-releasing peptide mRNAs are differentially distributed in the rat nervous system. *J Neurosci* **10** (9), 2917 (1990).

128 Wang, R. et al., Expression of alpha 2-adrenergic receptor subtypes in the mouse brain: evaluation of spatial and temporal information imparted by 3 kb of 5' regulatory sequence for the alpha 2A AR-receptor gene in transgenic animals. *Neuroscience* **74** (1), 199 (1996).

129 Warden, M. K. and Young, W. S., 3rd, Distribution of cells containing mRNAs encoding substance P and neurokinin B in the rat central nervous system. *J Comp Neurol* **272** (1), 90 (1988).

130 Wenzel, A., Fritschy, J. M., Mohler, H., and Benke, D., NMDA receptor heterogeneity during postnatal development of the rat brain: differential expression of the NR2A, NR2B, and NR2C subunit proteins. *J Neurochem* **68** (2), 469 (1997).

131 Whiteaker, P. et al., An autoradiographic study of the distribution of binding sites for the novel alpha7-selective nicotinic radioligand [3H]-methyllycaconitine in the mouse brain. *Eur J Neurosci* **11** (8), 2689 (1999).

132 Wisden, W., Laurie, D. J., Monyer, H., and Seeburg, P. H., The distribution of 13 GABAA receptor subunit mRNAs in the rat brain. I. Telencephalon, diencephalon, mesencephalon. *J Neurosci* **12** (3), 1040 (1992).

133 Wright, D. E. et al., Comparative localization of serotonin1A, 1C, and 2 receptor subtype mRNAs in rat brain. *J Comp Neurol* **351** (3), 357 (1995).

134 Yajima, S. et al., Cloning and characterization of murine glial cell-derived neurotrophic factor inducible transcription factor (MGIF). *J Neurosci* **17** (22), 8657 (1997).

135 Yamada, K. et al., Detection of tyrosine hydroxylase and phenylethanolamine-N-methyltransferase messenger RNAs in the mouse adrenal gland and the brain by in situ hybridization. *Histochemistry* **97** (3), 201 (1992).

136 Yang, H. K. et al., Distribution of doublecortin expressing cells near the lateral ventricles in the adult mouse brain. *J Neurosci Res* **76** (3), 282 (2004).

137 Yoneshima, H. et al., Er81 is expressed in a subpopulation of layer 5 neurons in rodent and primate neocortices. *Neuroscience* **137** (2), 401 (2006).

138 Yu, F. H. et al., Sodium channel beta4, a new disulfide-linked auxiliary subunit with similarity to beta2. *J Neurosci* **23** (20), 7577 (2003).

139 Zagon, I. S., Isayama, T., and McLaughlin, P. J., Preproenkephalin mRNA expression in the developing and adult rat brain. *Brain Res Mol Brain Res* **21** (1-2), 85 (1994).

140 Zarbalis, K. and Wurst, W., Expression domains of murine ephrin-A5 in the pituitary and hypothalamus. *Mech Dev* **93** (1-2), 165 (2000).

141 Zavitsanou, K. et al., Somatostatin, cholecystokinin and neuropeptide Y mRNAs in normal and weaver mouse brain. *J Neural Transm* **109** (11), 1337 (2002).

142 Zhou, X. F., Parada, L. F., Soppet, D., and Rush, R. A., Distribution of trkB tyrosine kinase immunoreactivity in the rat central nervous system. *Brain Res* **622** (1-2), 63 (1993).

143 Zigman, J. M. et al., Expression of ghrelin receptor mRNA in the rat and the mouse brain. *J Comp Neurol* **494** (3), 528 (2006).