



Universiteit  
Leiden  
The Netherlands

## **Doublecortin-like knockdown in the adult mouse brain: implications for neurogenesis, neuroplasticity and behaviour**

Saaltink, D.J.

### **Citation**

Saaltink, D. J. (2014, June 5). *Doublecortin-like knockdown in the adult mouse brain: implications for neurogenesis, neuroplasticity and behaviour*. Retrieved from <https://hdl.handle.net/1887/25884>

Version: Corrected Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/25884>

**Note:** To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/25884> holds various files of this Leiden University dissertation.

**Author:** Saaltink, Dirk-Jan

**Title:** Doublecortin-like knockdown in the adult mouse brain: implications for neurogenesis, neuroplasticity and behaviour

**Issue Date:** 2014-06-05

# Chapter 9

## References



## References

- Ables JL, Decarolis NA, Johnson MA, Rivera PD, Gao Z, Cooper DC, Radtke F, Hsieh J, Eisch AJ (2010) Notch1 is required for maintenance of the reservoir of adult hippocampal stem cells. *J Neurosci* 30:10484-10492.
- Abrous DN, Koehl M, Le Moal M (2005) Adult neurogenesis: From precursors to network and physiology. *Physiological Reviews* 85:523-569.
- Abrous DN, Wojtowicz JM (2008) Neurogenesis and hippocampal memory system. In: *Adult Neurogenesis* (Gager FH, Kempermann G, Song H, eds), pp 445-462. New York: Cold Spring Harbor Laboratory Press.
- Acehan D, Vaz F, Houtkooper RH, James J, Moore V, Tokunaga C, Kulik W, Wansapura J, Toth MJ, Strauss A, Khuchua Z (2011) Cardiac and skeletal muscle defects in a mouse model of human Barth syndrome. *J Biol Chem* 286:899-908.
- Adjei S, Houck AL, Ma K, Wesson DW (2013) Age-dependent alterations in the number, volume, and localization of islands of Calleja within the olfactory tubercle. *Neurobiol Aging* 34:2676-2682.
- Aimone JB, Deng W, Gage FH (2010) Adult neurogenesis: integrating theories and separating functions. *Trends in Cognitive Sciences* 14:325-337.
- Aimone JB, Deng W, Gage FH (2011) Resolving New Memories: A Critical Look at the Dentate Gyrus, Adult Neurogenesis, and Pattern Separation. *Neuron* 70:589-596.
- Aimone JB, Wiles J, Gage FH (2006) Potential role for adult neurogenesis in the encoding of time in new memories. *Nature Neuroscience* 9:723-727.
- Airan RD, Meltzer LA, Roy M, Gong YQ, Chen H, Deisseroth K (2007) High-speed Imaging reveals neurophysiological links to behavior in an animal model of depression. *Science* 317:819-823.
- Altman J (1963) Autoradiographic investigation of cell proliferation in the brains of rats and cats. *Anat Rec* 145:573-591.
- Altman J (1969) Autoradiographic and histological studies of postnatal neurogenesis. IV. Cell proliferation and migration in the anterior forebrain, with special reference to persisting neurogenesis in the olfactory bulb. *J Comp Neurol* 137:433-457.
- Altman J, Das GD (1965) Autoradiographic and histological evidence of postnatal hippocampal neurogenesis in rats. *J Comp Neurol* 124:319-335.
- Alvarez-Buylla A, Lim DA (2004) For the long run: maintaining germinal niches in the adult brain. *Neuron* 41:683-686.
- Alvarez-Buylla A, Ling CY, Yu WS (1994) Contribution of neurons born during embryonic, juvenile, and adult life to the brain of adult canaries: regional specificity and delayed birth of neurons in the song-control nuclei. *J Comp Neurol* 347:233-248.
- Amaral DG, Scharfman HE, Lavenex P (2007) The dentate gyrus: fundamental neuroanatomical organization (dentate gyrus for dummies). *Prog Brain Res* 163:3-22.
- Amrein I, Slomianka L, Lipp HP (2004a) Granule cell number, cell death and cell proliferation in the dentate gyrus of wild-living rodents. *European Journal of Neuroscience* 20:3342-3350.
- Amrein I, Slomianka L, Poletaeva II, Bologova NV, Lipp HP (2004b) Marked species and age-dependent differences in cell proliferation and neurogenesis in the hippocampus of wild-living rodents. *Hippocampus* 14:1000-1010.

- Andrews-Hanna JR, Snyder AZ, Vincent JL, Lustig C, Head D, Raichle ME, Buckner RL (2007) Disruption of large-scale brain systems in advanced aging. *Neuron* 56:924-935.
- Anthony TE, Klein C, Fishell G, Heintz N (2004) Radial glia serve as neuronal progenitors in all regions of the central nervous system. *Neuron* 41:881-890.
- Arruda-Carvalho M, Sakaguchi M, Akers KG, Josselyn SA, Frankland PW (2011) Posttraining ablation of adult-generated neurons degrades previously acquired memories. *J Neurosci* 31:15113-15127.
- Avgustinovich DF, Lipina TV, Bondar NP, Alekseyenko OV, Kudryavtseva NN (2000) Features of the genetically defined anxiety in mice. *Behav Genet* 30:101-109.
- Ayala R, Shu TZ, Tsai LH (2007) Trekking across the brain: The journey of neuronal migration. *Cell* 128:29-43.
- Bai JL, Ramos RL, Ackman JB, Thomas AM, Lee RV, LoTurco JJ (2003) RNAi reveals doublecortin is required for radial migration in rat neocortex. *Nature Neuroscience* 6:1277-1283.
- Bain MJ, Dwyer SM, Rusak B (2004) Restraint stress affects hippocampal cell proliferation differently in rats and mice. *Neuroscience Letters* 368:7-10.
- Baroncini M, Allet C, Leroy D, Beauvillain JC, Francke JP, Prevot V (2007) Morphological evidence for direct interaction between gonadotrophin-releasing hormone neurones and astroglial cells in the human hypothalamus. *J Neuroendocrinol* 19:691-702.
- Bassett JH, Harvey CB, Williams GR (2003) Mechanisms of thyroid hormone receptor-specific nuclear and extra nuclear actions. *Mol Cell Endocrinol* 213:1-11.
- Bauer S, Hay M, Amilhon B, Jean A, Moyse E (2005) In vivo neurogenesis in the dorsal vagal complex of the adult rat brainstem. *Neuroscience* 130:75-90.
- Becquet D, Girardet C, Guillaumond F, Francois-Bellan AM, Bosler O (2008) Ultrastructural plasticity in the rat Suprachiasmatic nucleus. Possible involvement in clock entrainment. *Glia* 56:294-305.
- Bedard A, Gravel C, Parent A (2006) Chemical characterization of newly generated neurons in the striatum of adult primates. *Exp Brain Res* 170:501-512.
- Bedard A, Levesque M, Bernier PJ, Parent A (2002) The rostral migratory stream in adult squirrel monkeys: contribution of new neurons to the olfactory tubercle and involvement of the antiapoptotic protein Bcl-2. *Eur J Neurosci* 16:1917-1924.
- Belnoue L, Grosjean N, Ladeveze E, Abrous DN, Koehl M (2013) Prenatal stress inhibits hippocampal neurogenesis but spares olfactory bulb neurogenesis. *PLoS One* 8:e72972.
- Belvindrah R, Nissant A, Lledo PM (2011) Abnormal Neuronal Migration Changes the Fate of Developing Neurons in the Postnatal Olfactory Bulb. *Journal of Neuroscience* 31:7551-7562.
- Berke JD, Paletzki RF, Aronson GJ, Hyman SE, Gerfen CR (1998) A complex program of striatal gene expression induced by dopaminergic stimulation. *J Neurosci* 18:5301-5310.
- Bernal J (2002) Action of thyroid hormone in brain. *J Endocrinol Invest* 25:268-288.
- Bernier PJ, Bedard A, Vinet J, Levesque M, Parent A (2002) Newly generated neurons in the amygdala and adjoining cortex of adult primates. *Proc Natl Acad Sci U S A* 99:11464-11469.

## References

- Bessa JM, Ferreira D, Melo I, Marques F, Cerqueira JJ, Palha JA, Almeida OF, Sousa N (2008) The mood-improving actions of antidepressants do not depend on neurogenesis but are associated with neuronal remodeling. *Mol Psychiatry*.
- Bessa JM, Ferreira D, Melo I, Marques F, Cerqueira JJ, Palha JA, Almeida OF, Sousa N (2009) The mood-improving actions of antidepressants do not depend on neurogenesis but are associated with neuronal remodeling. *Molecular Psychiatry* 14:764-773.
- Biancardi VC, Campos RR, Stern JE (2010) Altered Balance of gamma-Aminobutyric Acidergic and Glutamatergic Afferent Inputs in Rostral Ventrolateral Medulla-Projecting Neurons in the Paraventricular Nucleus of the Hypothalamus of Renovascular Hypertensive Rats. *Journal of Comparative Neurology* 518:567-585.
- Biebl M, Cooper CM, Winkler J, Kuhn HG (2000) Analysis of neurogenesis and programmed cell death reveals a self-renewing capacity in the adult rat brain. *Neurosci Lett* 291:17-20.
- Bloch J, Kaeser M, Sadeghi Y, Rouiller EM, Redmond DE, Jr., Brunet JF (2011) Doublecortin-positive cells in the adult primate cerebral cortex and possible role in brain plasticity and development. *J Comp Neurol* 519:775-789.
- Boekhoorn K, Sarabdjitsingh A, Kommerie H, de PK, Schouten T, Lucassen PJ, Vreugdenhil E (2008) Doublecortin (DCX) and doublecortin-like (DCL) are differentially expressed in the early but not late stages of murine neocortical development. *J Comp Neurol* 507:1639-1652.
- Bolborea M, Dale N (2013) Hypothalamic tanycytes: potential roles in the control of feeding and energy balance. *Trends Neurosci* 36:91-100.
- Bolborea M, Laran-Chich MP, Rasri K, Hildebrandt H, Govitrapong P, Simonneaux V, Pevet P, Steinlechner S, Klosien P (2011) Melatonin controls photoperiodic changes in tanycyte vimentin and neural cell adhesion molecule expression in the Djungarian hamster (*Phodopus sungorus*). *Endocrinology* 152:3871-3883.
- Boldrini M, Underwood MD, Hen R, Rosoklija GB, Dwork AJ, Mann JJ, Arango V (2009) Antidepressants increase neural progenitor cells in the human hippocampus. *Neuropsychopharmacology* 34:2376-2389.
- Bonfanti L (2006) PSA-NCAM in mammalian structural plasticity and neurogenesis. *Progress in Neurobiology* 80:129-164.
- Bonfanti L, Olive S, Poulain DA, Theodosis DT (1992) Mapping of the Distribution of Polysialylated Neural Cell-Adhesion Molecule Throughout the Central-Nervous-System of the Adult-Rat - An Immunohistochemical Study. *Neuroscience* 49:419-436.
- Bonfanti L, Peretto P (2011) Adult neurogenesis in mammals--a theme with many variations. *Eur J Neurosci* 34:930-950.
- Branda CS, Dymecki SM (2004) Talking about a revolution: The impact of site-specific recombinases on genetic analyses in mice. *Developmental Cell* 6:7-28.
- Bratincsak A, McMullen D, Miyake S, Toth ZE, Hallenbeck JM, Palkovits M (2007) Spatial and temporal activation of brain regions in hibernation: c-fos expression during the hibernation bout in thirteen-lined ground squirrel. *J Comp Neurol* 505:443-458.
- Bremner JD, Narayan M, Anderson ER, Staib LH, Miller HL, Charney DS (2000) Hippocampal volume reduction in major depression. *American Journal of Psychiatry* 157:115-117.
- Brinks V, Berger S, Gass P, de Kloet ER, Oitzl MS (2009) Mineralocorticoid receptors in control of emotional arousal and fear memory. *Horm Behav* 56:232-238.

- Brown J, Cooper-Kuhn CM, Kempermann G, van Praag H, Winkler J, Gage FH, Kuhn HG (2003a) Enriched environment and physical activity stimulate hippocampal but not olfactory bulb neurogenesis. *European Journal of Neuroscience* 17:2042-2046.
- Brown JP, Couillard-Despres S, Cooper-Kuhn CM, Winkler J, Aigner L, Kuhn HG (2003b) Transient expression of doublecortin during adult neurogenesis. *Journal of Comparative Neurology* 467:1-10.
- Burgess HA, Martinez S, Reiner O (1999) KIAA0369, doublecortin-like kinase, is expressed during brain development. *Journal of Neuroscience Research* 58:567-575.
- Burgess HA, Reiner O (2001) Cleavage of doublecortin-like kinase by calpain releases an active kinase fragment from a microtubule anchorage domain. *J Biol Chem* 276:36397-36403.
- Burgess HA, Reiner O (2000) Doublecortin-like kinase is associated with microtubules in neuronal growth cones. *Molecular and Cellular Neuroscience* 16:529-541.
- Burgess HA, Reiner O (2002) Alternative splice variants of doublecortin-like kinase are differentially expressed and have different kinase activities. *Journal of Biological Chemistry* 277:17696-17705.
- Cai Y, Xiong K, Chu Y, Luo DW, Luo XG, Yuan XY, Struble RG, Clough RW, Spencer DD, Williamson A, Kordower JH, Patrylo PR, Yan XX (2009) Doublecortin expression in adult cat and primate cerebral cortex relates to immature neurons that develop into GABAergic subgroups. *Exp Neurol* 216:342-356.
- Cameron HA, Gould E (1994) Adult neurogenesis is regulated by adrenal steroids in the dentate gyrus. *Neuroscience* 61:203-209.
- Cameron HA, Tanapat P, Gould E (1998) Adrenal steroids and N-methyl-D-aspartate receptor activation regulate neurogenesis in the dentate gyrus of adult rats through a common pathway. *Neuroscience* 82:349-354.
- Chauvet N, Prieto M, Alonso G (1998) Tanycytes present in the adult rat mediobasal hypothalamus support the regeneration of monoaminergic axons. *Exp Neurol* 151:1-13.
- Cheng MF (2013) Hypothalamic neurogenesis in the adult brain. *Front Neuroendocrinol* 34:167-178.
- Cierpicki T, Kim MH, Cooper DR, Derewenda U, Bushweller JH, Derewenda ZS (2006) The DC-module of doublecortin: dynamics, domain boundaries, and functional implications. *Proteins* 64:874-882.
- Cifuentes M, Perez-Martin M, Grondona JM, Lopez-Avalos MD, Inagaki N, Granados-Duran P, Rivera P, Fernandez-Llebrez P (2011) A comparative analysis of intraperitoneal versus intracerebroventricular administration of bromodeoxyuridine for the study of cell proliferation in the adult rat brain. *J Neurosci Methods* 201:307-314.
- Clark PJ, Brzezinska WJ, Thomas MW, Ryzhenko NA, Toshkov SA, Rhodes JS (2008) Intact neurogenesis is required for benefits of exercise on spatial memory but not motor performance or contextual fear conditioning in C57BL/6J mice. *Neuroscience* 155:1048-1058.
- Clelland CD, Choi M, Romberg C, Clemenson GD, Jr., Fragniere A, Tyers P, Jessberger S, Saksida LM, Barker RA, Gage FH, Bussey TJ (2009) A functional role for adult hippocampal neurogenesis in spatial pattern separation. *Science* 325:210-213.
- Coppola A, Liu ZW, Andrews ZB, Paradis E, Roy MC, Friedman JM, Ricquier D, Richard D, Horvath TL, Gao XB, Diano S (2007) A central thermogenic-like mechanism in feeding regulation: an interplay between arcuate nucleus T3 and UCP2. *Cell Metab* 5:21-33.
- Coquelle FM, Levy T, Bergmann S, Wolf SG, Bar-El D, Sapir T, Brody Y, Orr I, Barkai N, Eichele G, Reiner O (2006) Common and divergent roles for members of the mouse DCX superfamily. *Cell Cycle* 5:976-983.

## References

- Corbo JC, Deuel TA, Long JM, LaPorte P, Tsai E, Wynshaw-Boris A, Walsh CA (2002) Doublecortin is required in mice for lamination of the hippocampus but not the neocortex. *Journal of Neuroscience* 22:7548-7557.
- Couillard-Despres S, Winner B, Karl C, Lindemann G, Schmid P, Aigner R, Laemke J, Bogdahn U, Winkler J, Bischofberger J, Aigner L (2006) Targeted transgene expression in neuronal precursors: watching young neurons in the old brain. *European Journal of Neuroscience* 24:1535-1545.
- Couillard-Despres S, Winner B, Schaubeck S, Aigner R, Vroemen M, Weidner N, Bogdahn U, Winkler J, Kuhn HG, Aigner L (2005) Doublecortin expression levels in adult brain reflect neurogenesis. *Eur J Neurosci* 21:1-14.
- Crantz FR, Silva JE, Larsen PR (1982) An analysis of the sources and quantity of 3,5,3'-triiodothyronine specifically bound to nuclear receptors in rat cerebral cortex and cerebellum. *Endocrinology* 110:367-375.
- Curtis MA, Kam M, Faull RL (2011) Neurogenesis in humans. *Eur J Neurosci* 33:1170-1174.
- Curtis MA, Kam M, Nannmark U, Anderson MF, Axell MZ, Wikkelsö C, Holtas S, van Roon-Mom WM, Björk-Eriksson T, Nordborg C, Frisen J, Dragunow M, Faull RL, Eriksson PS (2007) Human neuroblasts migrate to the olfactory bulb via a lateral ventricular extension. *Science* 315:1243-1249.
- Curtis MA, Penney EB, Pearson AG, van Roon-Mom WM, Butterworth NJ, Dragunow M, Connor B, Faull RL (2003) Increased cell proliferation and neurogenesis in the adult human Huntington's disease brain. *Proc Natl Acad Sci U S A* 100:9023-9027.
- Czeh B, Lucassen PJ (2007) What causes the hippocampal volume decrease in depression? : Are neurogenesis, glial changes and apoptosis implicated? *Eur Arch Psychiatry Clin Neurosci* 257:250-260.
- Czeh B, Michaelis T, Watanabe T, Frahm J, de Biurrun G, van Kampen M, Bartolomucci A, Fuchs E (2001) Stress-induced changes in cerebral metabolites, hippocampal volume, and cell proliferation are prevented by antidepressant treatment with tianeptine. *Proceedings of the National Academy of Sciences of the United States of America* 98:12796-12801.
- Dalm S, Schwabe L, Schachinger H, Oitzl MS (2009) Post-training self administration of sugar facilitates cognitive performance of male C57BL/6J mice in two spatial learning tasks. *Behav Brain Res* 198:98-104.
- David DJ, Samuels BA, Rainer Q, Wang JW, Marsteller D, Mendez I, Drew M, Craig DA, Guindé BP, Guilloux JP, Artymyshyn RP, Gardier AM, Gerald C, Antonijevic IA, Leonardo ED, Hen R (2009) Neurogenesis-Dependent and -Independent Effects of Fluoxetine in an Animal Model of Anxiety/Depression. *Neuron* 62:479-493.
- David DJ, Wang JW, Samuels BA, Rainer Q, David I, Gardier AM, Hen R (2010) Implications of the Functional Integration of Adult-Born Hippocampal Neurons in Anxiety-Depression Disorders. *Neuroscientist* 16:578-591.
- Dayer AG, Cleaver KM, Abouantoun T, Cameron HA (2005) New GABAergic interneurons in the adult neocortex and striatum are generated from different precursors. *J Cell Biol* 168:415-427.
- de Kloet ER, Joels M, Holsboer F (2005) Stress and the brain: From adaptation to disease. *Nature Reviews Neuroscience* 6:463-475.
- de Kloet ER, Oitzl MS, Joels M (1999) Stress and cognition: are corticosteroids good or bad guys? *Trends Neurosci* 22:422-426.
- de Kloet ER, Vreugdenhil E, Oitzl MS, Joels M (1998) Brain corticosteroid receptor balance in health and disease. *Endocrine Reviews* 19:269-301.
- De Marchis S, Fasolo A, Puche AC (2004) Subventricular zone-derived neuronal progenitors migrate into the subcortical forebrain of postnatal mice. *Journal of Comparative Neurology* 476:290-300.

- De MS, Fasolo A, Puche AC (2004) Subventricular zone-derived neuronal progenitors migrate into the subcortical forebrain of postnatal mice. *J Comp Neurol* 476:290-300.
- Deacon RM, Croucher A, Rawlins JN (2002) Hippocampal cytotoxic lesion effects on species-typical behaviours in mice. *Behav Brain Res* 132:203-213.
- Dehmelt L, Halpain S (2004) Actin and microtubules in neurite initiation: Are MAPs the missing link? *Journal of Neurobiology* 58:18-33.
- Dehmelt L, Halpain S (2007) Neurite outgrowth: A flick of the wrist. *Current Biology* 17:R611-R614.
- Deng W, Aimone JB, Gage FH (2010) New neurons and new memories: how does adult hippocampal neurogenesis affect learning and memory? *Nat Rev Neurosci*.
- Denny CA, Burghardt NS, Schachter DM, Hen R, Drew MR (2012) 4- to 6-week-old adult-born hippocampal neurons influence novelty-evoked exploration and contextual fear conditioning. *Hippocampus* 22:1188-1201.
- des Portes V, Pinard JM, Billuart P, Vinet MC, Koulakoff A, Carrie A, Gelot A, Dupuis E, Motte J, Berwald-Netter Y, Catala M, Kahn A, Beldjord C, Chelly J (1998) A novel CNS gene required for neuronal migration and involved in X-linked subcortical laminar heterotopia and lissencephaly syndrome. *Cell* 92:51-61.
- Deuel TAS, Liu JS, Corbo JC, Yoo SY, Rorke-Adams LB, Walsh CA (2006) Genetic interactions between doublecortin and doublecortin-like kinase in neuronal migration and axon outgrowth. *Neuron* 49:41-53.
- Dhaliwal J, Lagace DC (2011) Visualization and genetic manipulation of adult neurogenesis using transgenic mice. *Eur J Neurosci* 33:1025-1036.
- Dickmeis T, Foulkes NS (2011) Glucocorticoids and circadian clock control of cell proliferation: At the interface between three dynamic systems. *Molecular and Cellular Endocrinology* 331:11-22.
- Dietrich MO, Horvath TL (2012) Fat incites tanycytes to neurogenesis. *Nat Neurosci* 15:651-653.
- Dijkmans TF, van Hooijdonk LW, Fitzsimons CP, Vreugdenhil E (2010) The doublecortin gene family and disorders of neuronal structure. *Cent Nerv Syst Agents Med Chem* 10:32-46.
- Dijkmans TF, van Hooijdonk LW, Schouten TG, Kamphorst JT, Vellinga AC, Meerman JH, Fitzsimons CP, de Kloet ER, Vreugdenhil E (2008) Temporal and functional dynamics of the transcriptome during nerve growth factor-induced differentiation. *J Neurochem* 105:2388-2403.
- Dityatev A, Dityateva G, Sytnyk V, Delling M, Toni N, Nikonenko I, Muller D, Schachner M (2004) Polysialylated neural cell adhesion molecule promotes remodeling and formation of hippocampal synapses. *Journal of Neuroscience* 24:9372-9382.
- Dobrossy MD, Drapeau E, Auroousseau C, Le MM, Piazza PV, Abrous DN (2003) Differential effects of learning on neurogenesis: learning increases or decreases the number of newly born cells depending on their birth date. *Mol Psychiatry* 8:974-982.
- Doetsch F, GarciaVerdugo JM, AlvarezBuylla A (1997) Cellular composition and three-dimensional organization of the subventricular germinal zone in the adult mammalian brain. *Journal of Neuroscience* 17:5046-5061.
- Dong H, Goico B, Martin M, Csernansky CA, Bertchume A, Csernansky JG (2004) Modulation of hippocampal cell proliferation, memory, and amyloid plaque deposition in APPsw (Tg2576) mutant mice by isolation stress. *Neuroscience* 127:601-609.
- Drew MR, Denny CA, Hen R (2010) Arrest of adult hippocampal neurogenesis in mice impairs single- but not multiple-trial contextual fear conditioning. *Behav Neurosci* 124:446-454.

## References

- Duan X, Chang JH, Ge S, Faulkner RL, Kim JY, Kitabatake Y, Liu XB, Yang CH, Jordan JD, Ma DK, Liu CY, Ganesan S, Cheng HJ, Ming GL, Lu B, Song H (2007) Disrupted-In-Schizophrenia 1 Regulates Integration of Newly Generated Neurons in the Adult Brain. *Cell* 130:1146-1158.
- Duan X, Kang EC, Liu CY, Ming GL, Song HJ (2008) Development of neural stem cell in the adult brain. *Current Opinion in Neurobiology* 18:108-115.
- Duman RS (2004) Depression: A case of neuronal life and death? *Biological Psychiatry* 56:140-145.
- Dupret D, Fabre A, Dobrossy MD, Panatier A, Rodriguez JJ, Lamarque S, Lemaire V, Oliet SH, Piazza PV, Abrous DN (2007) Spatial learning depends on both the addition and removal of new hippocampal neurons. *PLoS Biol* 5:e214.
- Dupret D, Revest JM, Koehl M, Ichas F, De GF, Costet P, Abrous DN, Piazza PV (2008) Spatial relational memory requires hippocampal adult neurogenesis. *PLoS ONE* 3:e1959.
- Earnheart JC, Schweizer C, Crestani F, Iwasato T, Itohara S, Mohler H, Luscher B (2007) GABAergic control of adult hippocampal neurogenesis in relation to behavior indicative of trait anxiety and depression states. *J Neurosci* 27:3845-3854.
- Edelman AM, Kim WY, Higgins D, Goldstein EG, Oberdoerster M, Sigurdson W (2005) Doublecortin kinase-2, a novel doublecortin-related protein kinase associated with terminal segments of axons and dendrites. *Journal of Biological Chemistry* 280:8531-8543.
- Encinas JM, Vaahtokari A, Enikolopov G (2006) Fluoxetine targets early progenitor cells in the adult brain. *Proc Natl Acad Sci U S A* 103:8233-8238.
- Engels BM, Schouten TG, van Dulleman J, Gosens I, Vreugdenhil E (2004) Functional differences between two DCLK splice variants. *Molecular Brain Research* 120:103-114.
- Ennis M, Hamilton KA, Hayar A (2007) Neurochemistry of the Main Olfactory System. In: *Handbook of Neurochemistry and Molecular Neurobiology; Sensory Neurochemistry* (Johnson, Lajtha, eds), pp 137-204. Springer Science.
- Epp JR, Barker JM, Galea LA (2009) Running wild: neurogenesis in the hippocampus across the lifespan in wild and laboratory-bred Norway rats. *Hippocampus* 19:1040-1049.
- Eriksson PS, Perfilieva E, Bjork-Eriksson T, Alborn AM, Nordborg C, Peterson DA, Gage FH (1998) Neurogenesis in the adult human hippocampus. *Nature Medicine* 4:1313-1317.
- Esposito MS, Piatti VC, Laplagne DA, Morgenstern NA, Ferrari CC, Pitossi FJ, Schinder AF (2005) Neuronal differentiation in the adult hippocampus recapitulates embryonic development. *J Neurosci* 25:10074-10086.
- Falconer EM, Galea LAM (2003) Sex differences in cell proliferation, cell death and defensive behavior following acute predator odor stress in adult rats. *Brain Research* 975:22-36.
- Fallon JH (1983) The Islands of Calleja Complex of Rat Basal Forebrain .2. Connections of Medium and Large Sized Cells. *Brain Research Bulletin* 10:775-793.
- Fallon JH, Loughlin SE, Ribak CE (1983) The Islands of Calleja Complex of Rat Basal Forebrain .3. Histochemical Evidence for A Striatopallidal System. *Journal of Comparative Neurology* 218:91-120.
- Fallon JH, Riley JN, Sipe JC, Moore RY (1978) Islands of Calleja - Organization and Connections. *Journal of Comparative Neurology* 181:375-394.
- Farmer J, Zhao X, van Praag H, Wodtke K, Gage FH, Christie BR (2004) Effects of voluntary exercise on synaptic plasticity and gene expression in the dentate gyrus of adult male Sprague-Dawley rats in vivo. *Neuroscience* 124:71-79.

- Faulkner RL, Jang MH, Liu XB, Duan X, Sailor KA, Kim JY, Ge S, Jones EG, Ming GL, Song H, Cheng HJ (2008) Development of hippocampal mossy fiber synaptic outputs by new neurons in the adult brain. *Proc Natl Acad Sci U S A* 105:14157-14162.
- Favaro R, Valotta M, Ferri AL, Latorre E, Mariani J, Giachino C, Lancini C, Tosetti V, Ottolenghi S, Taylor V, Nicolis SK (2009) Hippocampal development and neural stem cell maintenance require Sox2-dependent regulation of Shh. *Nat Neurosci* 12:1248-1256.
- Fediuc S, Campbell JE, Riddell MC (2006) Effect of voluntary wheel running on circadian corticosterone release and on HPA axis responsiveness to restraint stress in Sprague-Dawley rats. *J Appl Physiol* 100:1867-1875.
- Fedorkova L, Rutishauser U, Prosser R, Shen FM, Glass JD (2002) Removal of polysialic acid from the SCN potentiates nonphotic circadian phase resetting. *Physiology & Behavior* 77:361-369.
- Fekete C, Lechan RM (2007) Negative feedback regulation of hypophysiotropic thyrotropin-releasing hormone (TRH) synthesizing neurons: role of neuronal afferents and type 2 deiodinase. *Front Neuroendocrinol* 28:97-114.
- Femia AP, Dolara P, Salvadori M, Caderni G (2013) Expression of LGR-5, MSI-1 and DCAMKL-1, putative stem cell markers, in the early phases of 1,2-dimethylhydrazine-induced rat colon carcinogenesis: correlation with nuclear beta-catenin. *BMC Cancer* 13:48.
- Finkbeiner S, Tavazoie SF, Maloratsky A, Jacobs KM, Harris KM, Greenberg ME (1997) CREB: a major mediator of neuronal neurotrophin responses. *Neuron* 19:1031-1047.
- Fitzsimons CP, Ahmed S, Wittevrongel CF, Schouten TG, Dijkmans TF, Scheenen WJ, Schaaf MJ, de Kloet ER, Vreugdenhil E (2008) The microtubule-associated protein doublecortin-like regulates the transport of the glucocorticoid receptor in neuronal progenitor cells. *Mol Endocrinol* 22:248-262.
- Fitzsimons CP, van Hooijdonk LW, Schouten M, Zalachoras I, Brinks V, Zheng T, Schouten TG, Saaltink DJ, Dijkmans T, Steindler DA, Verhaagen J, Verbeek FJ, Lucassen PJ, de Kloet ER, Meijer OC, Karst H, Joels M, Oitzl MS, Vreugdenhil E (2013) Knockdown of the glucocorticoid receptor alters functional integration of newborn neurons in the adult hippocampus and impairs fear-motivated behavior. *Mol Psychiatry* 18:993-1005.
- Fowler CD, Johnson F, Wang ZX (2005) Estrogen regulation of cell proliferation and distribution of estrogen receptor-alpha in the brains of adult female prairie and meadow voles. *Journal of Comparative Neurology* 489:166-179.
- Fowler CD, Liu Y, Ouimet C, Wang Z (2002) The effects of social environment on adult neurogenesis in the female prairie vole. *Journal of Neurobiology* 51:115-128.
- Francis F, Koulakoff A, Boucher D, Chafey P, Schaar B, Vinet MC, Friocourt G, McDonnell N, Reiner O, Kahn A, McConnell SK, Berwald-Netter Y, Denoulet P, Chelly J (1999) Doublecortin is a developmentally regulated, microtubule-associated protein expressed in migrating and differentiating neurons. *Neuron* 23:247-256.
- Frankland PW (2013) Neurogenic evangelism: comment on Urbach et al. (2013). *Behav Neurosci* 127:126-129.
- Franklin K.B.J. aPG (1997) *The Mouse Brain in Stereotaxic Coordinates*. San Diego: Academic Press.
- Frayling C, Britton R, Dale N (2011) ATP-mediated glucosensing by hypothalamic tanycytes. *J Physiol* 589:2275-2286.
- Frielingsdorf H, Schwarz K, Brundin P, Mohapel P (2004) No evidence for new dopaminergic neurons in the adult mammalian substantia nigra. *Proc Natl Acad Sci U S A* 101:10177-10182.
- Friocourt G, Chafey P, Billuart P, Koulakoff A, Vinet MC, Schaar BT, McConnell SK, Francis F, Chelly J (2001) Doublecortin interacts with mu subunits of clathrin adaptor complexes in the developing nervous system. *Mol Cell Neurosci* 18:307-319.

## References

- Friocourt G, Koulakoff A, Chafey P, Boucher D, Fauchereau F, Chelly J, Francis F (2003) Doublecortin functions at the extremities of growing neuronal processes. *Cerebral Cortex* 13:620-626.
- Friocourt G, Liu JS, Antypa M, Rakic S, Walsh CA, Parnavelas JG (2007) Both doublecortin and doublecortin-like kinase play a role in cortical interneuron migration. *Journal of Neuroscience* 27:3875-3883.
- Fukuda S, Kato F, Tozuka Y, Yamaguchi M, Miyamoto Y, Hisatsune T (2003) Two distinct subpopulations of nestin-positive cells in adult mouse dentate gyrus. *J Neurosci* 23:9357-9366.
- Fuss J, Ben Abdallah NMB, Hensley FW, Weber KJ, Hellweg R, Gass P (2010) Deletion of Running-Induced Hippocampal Neurogenesis by Irradiation Prevents Development of an Anxious Phenotype in Mice. *Plos One* 5.
- Gao Z, Ure K, Ables JL, Lagace DC, Nave KA, Goebbels S, Eisch AJ, Hsieh J (2009) Neurod1 is essential for the survival and maturation of adult-born neurons. *Nat Neurosci* 12:1090-1092.
- Garcia A, Steiner B, Kronenberg G, Bick-Sander A, Kempermann G (2004) Age-dependent expression of glucocorticoid- and mineralocorticoid receptors on neural precursor cell populations in the adult murine hippocampus. *Aging Cell* 3:363-371.
- Ge S, Goh EL, Sailor KA, Kitabatake Y, Ming GL, Song H (2006) GABA regulates synaptic integration of newly generated neurons in the adult brain. *Nature* 439:589-593.
- Geoghegan D, Carter DA (2008) A novel site of adult doublecortin expression: neuropeptide neurons within the suprachiasmatic nucleus circadian clock. *Bmc Neuroscience* 9.
- Gereben B, Goncalves C, Harney JW, Larsen PR, Bianco AC (2000) Selective proteolysis of human type 2 deiodinase: a novel ubiquitin-proteasomal mediated mechanism for regulation of hormone activation. *Mol Endocrinol* 14:1697-1708.
- Gerritsen L, Comijs HC, van der Graaf Y, Knoop AJG, Penninx BWJH, Geerlings MI (2011) Depression, Hypothalamic Pituitary Adrenal Axis, and Hippocampal and Entorhinal Cortex Volumes-The SMART Medea Study. *Biological Psychiatry* 70:373-380.
- Gheusi G, Cremer H, McLean H, Chazal G, Vincent JD, Lledo PM (2000) Importance of newly generated neurons in the adult olfactory bulb for odor discrimination. *Proc Natl Acad Sci U S A* 97:1823-1828.
- Girardet C, Becquet D, Blanchard MP, Francois-Bellan AM, Bosler O (2010a) Neuroglial and synaptic rearrangements associated with photic entrainment of the circadian clock in the suprachiasmatic nucleus. *European Journal of Neuroscience* 32:2133-2142.
- Girardet C, Blanchard MP, Ferracci G, Leveque C, Moreno M, Francois-Bellan AM, Becquet D, Bosler O (2010b) Daily changes in synaptic innervation of VIP neurons in the rat suprachiasmatic nucleus: contribution of glutamatergic afferents. *European Journal of Neuroscience* 31:359-370.
- Glass JD, Watanabe M, Fedorkova L, Shen H, Ungers G, Rutishauser U (2003) Dynamic regulation of polysialylated neural cell adhesion molecule in the suprachiasmatic nucleus. *Neuroscience* 117:203-211.
- Glavan G, Sket D, Zivin M (2002) Modulation of neuroleptic activity of 9,10-didehydro-N-methyl-(2-propynyl)-6-methyl-8-aminomethylergoline bimalate (LEK-8829) by D1 intrinsic activity in hemi-parkinsonian rats. *Mol Pharmacol* 61:360-368.
- Gleeson JG, Allen KM, Fox JW, Lamperti ED, Berkovic S, Scheffer I, Cooper EC, Dobyns WB, Minnerath SR, Ross ME, Walsh CA (1998) doublecortin, a brain-specific gene mutated in human X-linked lissencephaly and double cortex syndrome, encodes a putative signaling protein. *Cell* 92:63-72.

- Gleeson JG, Lin PT, Flanagan LA, Walsh CA (1999) Doublecortin is a microtubule-associated protein and is expressed widely by migrating neurons. *Neuron* 23:257-271.
- Gold PW, Chrousos GP (2002) Organization of the stress system and its dysregulation in melancholic and atypical depression: high vs low CRH/NE states. *Molecular Psychiatry* 7:254-275.
- Goldman SA, Nottebohm F (1983) Neuronal production, migration, and differentiation in a vocal control nucleus of the adult female canary brain. *Proc Natl Acad Sci U S A* 80:2390-2394.
- Gomez-Climent MA, Castillo-Gomez E, Varea E, Guirado R, Blasco-Ibanez JM, Crespo C, Martinez-Guijarro FJ, Nacher J (2008) A population of prenatally generated cells in the rat paleocortex maintains an immature neuronal phenotype into adulthood. *Cereb Cortex* 18:2229-2240.
- Gonczy P, Bellanger JM, Kirkham M, Pozniakowski A, Baumer K, Phillips JB, Hyman AA (2001) *zvg-8*, a gene required for spindle positioning in *C-elegans*, encodes a doublecortin-related kinase that promotes microtubule assembly. *Developmental Cell* 1:363-375.
- Gould E (2007) Opinion - How widespread is adult neurogenesis in mammals? *Nature Reviews Neuroscience* 8:481-488.
- Gould E, Beylin A, Tanapat P, Reeves A, Shors TJ (1999a) Learning enhances adult neurogenesis in the hippocampal formation. *Nature Neuroscience* 2:260-265.
- Gould E, Beylin A, Tanapat P, Reeves A, Shors TJ (1999b) Learning enhances adult neurogenesis in the hippocampal formation. *Nature Neuroscience* 2:260-265.
- Gould E, Cameron HA, Daniels DC, Woolley CS, Mcewen BS (1992) Adrenal Hormones Suppress Cell-Division in the Adult-Rat Dentate Gyrus. *Journal of Neuroscience* 12:3642-3650.
- Gould E, Mcewen BS, Tanapat P, Galea LAM, Fuchs E (1997) Neurogenesis in the dentate gyrus of the adult tree shrew is regulated by psychosocial stress and NMDA receptor activation. *Journal of Neuroscience* 17:2492-2498.
- Gould E, Reeves AJ, Graziano MSA, Gross CG (1999c) Neurogenesis in the neocortex of adult primates. *Science* 286:548-552.
- Gould E, Tanapat P, Mcewen BS, Flugge G, Fuchs E (1998) Proliferation of granule cell precursors in the dentate gyrus of adult monkeys is diminished by stress. *Proceedings of the National Academy of Sciences of the United States of America* 95:3168-3171.
- Grant E.C., Mackintosh J.H. (1963) A Comparison of the Social Postures of Some Common Laboratory Rodents. *Behaviour* 21:246-259.
- Gu Y, rruda-Carvalho M, Wang J, Janoschka SR, Josselyn SA, Frankland PW, Ge S (2012) Optical controlling reveals time-dependent roles for adult-born dentate granule cells. *Nat Neurosci* 15:1700-1706.
- Guadano-Ferraz A, Obregon MJ, St Germain DL, Bernal J (1997) The type 2 iodothyronine deiodinase is expressed primarily in glial cells in the neonatal rat brain. *Proc Natl Acad Sci U S A* 94:10391-10396.
- Gupta A, Tsai LH, Wynshaw-Boris A (2002) Life is a journey: a genetic look at neocortical development. *Nat Rev Genet* 3:342-355.
- Guzman-Marin R, Suntsova N, Bashir T, Szymusiak R, McGinty D (2007) Cell proliferation in the dentate gyrus of the adult rat fluctuates with the light-dark cycle. *Neuroscience Letters* 422:198-201.

## References

- Haan N, Goodman T, Najdi-Samiei A, Stratford CM, Rice R, El AE, Bellusci S, Hajihosseini MK (2013) Fgf10-expressing tanyocytes add new neurons to the appetite/energy-balance regulating centers of the postnatal and adult hypothalamus. *J Neurosci* 33:6170-6180.
- Hack MA, Saghatelian A, de CA, Pfeifer A, shery-Padan R, Lledo PM, Gotz M (2005) Neuronal fate determinants of adult olfactory bulb neurogenesis. *Nat Neurosci* 8:865-872.
- Hazlerigg D, Loudon A (2008) New insights into ancient seasonal life timers. *Current Biology* 18:R795-R804.
- He G, Luo W, Li P, Remmers C, Netzer WJ, Hendrick J, Bettayeb K, Flajolet M, Gorelick F, Wennogle LP, Greengard P (2010) Gamma-secretase activating protein is a therapeutic target for Alzheimer's disease. *Nature* 467:95-98.
- Heine VM, Maslam S, Joels M, Lucassen PJ (2004a) Prominent decline of newborn cell proliferation, differentiation, and apoptosis in the aging dentate gyrus, in absence of an age-related hypothalamus-pituitary-adrenal axis activation. *Neurobiol Aging* 25:361-375.
- Heine VM, Maslam S, Zareno J, Joels M, Lucassen PJ (2004b) Suppressed proliferation and apoptotic changes in the rat dentate gyrus after acute and chronic stress are reversible. *European Journal of Neuroscience* 19:131-144.
- Herrera DG, Garcia-Verdugo JM, varez-Buylla A (1999) Adult-derived neural precursors transplanted into multiple regions in the adult brain. *Ann Neurol* 46:867-877.
- Hof PR, Morrison JH (2004) The aging brain: morphomolecular senescence of cortical circuits. *Trends Neurosci* 27:607-613.
- Holick KA, Lee DC, Hen R, Dulawa SC (2008) Behavioral effects of chronic fluoxetine in BALB/cJ mice do not require adult hippocampal neurogenesis or the serotonin 1A receptor. *Neuropsychopharmacology* 33:406-417.
- Holsboer F, Ising M (2010) Stress Hormone Regulation: Biological Role and Translation into Therapy. *Annual Review of Psychology* 61:81-109.
- Horesh D, Sapir T, Francis F, Wolf SG, Caspi M, Elbaum M, Chelly J, Reiner O (1999) Doublecortin, a stabilizer of microtubules. *Human Molecular Genetics* 8:1599-1610.
- Huang GJ, Bannerman D, Flint J (2008) Chronic fluoxetine treatment alters behavior, but not adult hippocampal neurogenesis, in BALB/cJ mice. *Molecular Psychiatry* 13:119-121.
- Huang L, DeVries GJ, Bittman EL (1998) Photoperiod regulates neuronal bromodeoxyuridine labeling in the brain of a seasonally breeding mammal. *J Neurobiol* 36:410-420.
- Ibi D, Takuma K, Koike H, Mizoguchi H, Tsuritani K, Kuwahara Y, Kamei H, Nagai T, Yoneda Y, Nabeshima T, Yamada K (2007) Social isolation rearing-induced impairment of the hippocampal neurogenesis is associated with deficits in spatial memory and emotion-related behaviors in juvenile mice. *J Neurochem* ..
- Imayoshi I, Ohtsuka T, Metzger D, Chambon P, Kageyama R (2006) Temporal regulation of Cre recombinase activity in neural stem cells. *Genesis* 44:233-238.
- Imayoshi I, Sakamoto M, Kageyama R (2011) Genetic methods to identify and manipulate newly born neurons in the adult brain. *Front Neurosci* 5:64.
- Imayoshi I, Sakamoto M, Ohtsuka T, Takao K, Miyakawa T, Yamaguchi M, Mori K, Ikeda T, Itohara S, Kageyama R (2008) Roles of continuous neurogenesis in the structural and functional integrity of the adult forebrain. *Nat Neurosci* 11:1153-1161.

- Jacobs BL, van Praag H, Gage FH (2000) Adult brain neurogenesis and psychiatry: a novel theory of depression. *Molecular Psychiatry* 5:262-269.
- Jacobson L, Sapolsky R (1991) The Role of the Hippocampus in Feedback-Regulation of the Hypothalamic-Pituitary-Adrenocortical Axis. *Endocrine Reviews* 12:118-134.
- Jaenisch R, Mintz B (1974) Simian virus 40 DNA sequences in DNA of healthy adult mice derived from preimplantation blastocysts injected with viral DNA. *Proc Natl Acad Sci U S A* 71:1250-1254.
- Jaholkowski P, Kíryk A, Jedynak P, Ben Abdallah NM, Knapska E, Kowalczyk A, Piechal A, Blecharz-Klin K, Figiel I, Lioudyno V, Widy-Tyszkiewicz E, Wilczynski GM, Lipp HP, Kaczmarek L, Filipkowski RK (2009) New hippocampal neurons are not obligatory for memory formation; cyclin D2 knockout mice with no adult brain neurogenesis show learning. *Learn Mem* 16:439-451.
- Jansen K, Van der Zee EA, Gerkema MP (2007) Vasopressin immunoreactivity, but not vasoactive intestinal polypeptide, correlates with expression of circadian rhythmicity in the suprachiasmatic nucleus of voles. *Neuropeptides* 41:207-216.
- Jansen K, Van der Zee EA, Gerkema MP (2000) Being circadian or not: vasopressin release in cultured SCN mirrors behavior in adult voles. *Neuroreport* 11:3555-3558.
- Jayatissa MN, Henningsen K, West MJ, Wiborg O (2009) Decreased cell proliferation in the dentate gyrus does not associate with development of anhedonic-like symptoms in rats. *Brain Research* 1290:133-141.
- Jedynak P, Jaholkowski P, Wozniak G, Sandi C, Kaczmarek L, Filipkowski RK (2012) Lack of cyclin D2 impairing adult brain neurogenesis alters hippocampal-dependent behavioral tasks without reducing learning ability. *Behav Brain Res* 227:159-166.
- Jessberger S, Romer B, Babu H, Kempermann G (2005) Seizures induce proliferation and dispersion of doublecortin-positive hippocampal progenitor cells. *Exp Neurol* 196:342-351.
- Jessberger S, Zhao C, Toni N, Clemenson GD, Jr., Li Y, Gage FH (2007) Seizure-associated, aberrant neurogenesis in adult rats characterized with retrovirus-mediated cell labeling. *J Neurosci* 27:9400-9407.
- Kalsbeek A, Buijs RM, van SR, Kaptein E, Visser TJ, Doulabi BZ, Fliers E (2005) Daily variations in type II iodothyronine deiodinase activity in the rat brain as controlled by the biological clock. *Endocrinology* 146:1418-1427.
- Kameda Y, Arai Y, Nishimaki T (2003) Ultrastructural localization of vimentin immunoreactivity and gene expression in tanycytes and their alterations in hamsters kept under different photoperiods. *Cell and Tissue Research* 314:251-262.
- Kannangara TS, Webber A, Gil-Mohapel J, Christie BR (2009) Stress Differentially Regulates the Effects of Voluntary Exercise on Cell Proliferation in the Dentate Gyrus of Mice. *Hippocampus* 19:889-897.
- Kaplan MS (1981) Neurogenesis in the 3-month-old rat visual cortex. *J Comp Neurol* 195:323-338.
- Kaplan MS, Hinds JW (1977) Neurogenesis in the adult rat: electron microscopic analysis of light radioautographs. *Science* 197:1092-1094.
- Kappeler C, Saillour Y, Baudoin JP, Tuy FPD, Alvarez C, Houbroun C, Gaspar P, Hamard G, Chelly J, Metin C, Francis F (2006) Branching and nucleokinesis defects in migrating interneurons derived from doublecortin knockout mice. *Human Molecular Genetics* 15:1387-1400.
- Karatsoreos IN, Yan L, LeSauter J, Silver R (2004) Phenotype matters: Identification of light-responsive cells in the mouse suprachiasmatic nucleus. *Journal of Neuroscience* 24:68-75.

## References

- Kee N, Teixeira CM, Wang AH, Frankland PW (2007) Preferential incorporation of adult-generated granule cells into spatial memory networks in the dentate gyrus. *Nat Neurosci* 10:355-362.
- Kempermann G (2012) New neurons for 'survival of the fittest'. *Nat Rev Neurosci* 13:727-736.
- Kempermann G (2008) The neurogenic reserve hypothesis: what is adult hippocampal neurogenesis good for? *Trends Neurosci* ..
- Kempermann G, Brandon EP, Gage FH (1998a) Environmental stimulation of 129/SvJ mice causes increased cell proliferation and neurogenesis in the adult dentate gyrus. *Curr Biol* 8:939-942.
- Kempermann G, Gast D, Kronenberg G, Yamaguchi M, Gage FH (2003) Early determination and long-term persistence of adult-generated new neurons in the hippocampus of mice. *Development* 130:391-399.
- Kempermann G, Kuhn HG, Gage FH (1997b) More hippocampal neurons in adult mice living in an enriched environment. *Nature* 386:493-495.
- Kempermann G, Kuhn HG, Gage FH (1997a) Genetic influence on neurogenesis in the dentate gyrus of adult mice. *Proc Natl Acad Sci U S A* 94:10409-10414.
- Kempermann G, Kuhn HG, Gage FH (1998b) Experience-induced neurogenesis in the senescent dentate gyrus. *Journal of Neuroscience* 18:3206-3212.
- Kempermann G, Song H, Gage FH (2008) Neurogenesis in the Adult Hippocampus. In: *Adult Neurogenesis* (Gage FH, Kempermann G, Song H, eds), pp 159-174. New York: Cold Spring Harbor Laboratory Press.
- Kheirbek MA, Drew LJ, Burghardt NS, Costantini DO, Tannenholz L, Ahmari SE, Zeng H, Fenton AA, Hen R (2013) Differential control of learning and anxiety along the dorsoventral axis of the dentate gyrus. *Neuron* 77:955-968.
- Kheirbek MA, Klemenhagen KC, Sahay A, Hen R (2012) Neurogenesis and generalization: a new approach to stratify and treat anxiety disorders. *Nat Neurosci* 15:1613-1620.
- Kikuchi M, Nagata H, Watanabe N, Watanabe H, Tatemichi M, Hibi T (2010) Altered expression of a putative progenitor cell marker DCAMKL1 in the rat gastric mucosa in regeneration, metaplasia and dysplasia. *BMC Gastroenterol* 10:65.
- Kim MH, Cierpicki T, Derewenda U, Krowarsch D, Feng YY, Devedjiev Y, Dauter Z, Walsh CA, Otlewski J, Bushweller JH, Derewenda ZS (2003) The DCX-domain tandems of doublecortin and doublecortin-like kinase. *Nature Structural Biology* 10:324-333.
- Kohwi M, Osumi N, Rubenstein JL, varez-Buylla A (2005) Pax6 is required for making specific subpopulations of granule and periglomerular neurons in the olfactory bulb. *J Neurosci* 25:6997-7003.
- Kohwi M, Petryniak MA, Long JE, Ekker M, Obata K, Yanagawa Y, Rubenstein JL, varez-Buylla A (2007) A subpopulation of olfactory bulb GABAergic interneurons is derived from Emx1- and Dlx5/6-expressing progenitors. *J Neurosci* 27:6878-6891.
- Koizumi H, Tanaka T, Gleeson JG (2006) Doublecortin-like kinase functions with doublecortin to mediate fiber tract decussation and neuronal migration. *Neuroscience Research* 55:S238.
- Kokoeva MV, Yin HL, Flier JS (2007) Evidence for constitutive neural cell proliferation in the adult murine hypothalamus. *Journal of Comparative Neurology* 505:209-220.
- Kokoeva MV, Yin HL, Flier JS (2005) Neurogenesis in the hypothalamus of adult mice: Potential role in energy balance. *Science* 310:679-683.

- Konefal S, Elliot M, Crespi B (2013) The adaptive significance of adult neurogenesis: an integrative approach. *Front Neuroanat* 7:21.
- Koopmans G, Blokland A, van NP, Prickaerts J (2003) Assessment of spatial learning abilities of mice in a new circular maze. *Physiol Behav* 79:683-693.
- Kosaka K, Aika Y, Toida K, Heizmann CW, Hunziker W, Jacobowitz DM, Nagatsu I, Streit P, Visser TJ, Kosaka T (1995) Chemically defined neuron groups and their subpopulations in the glomerular layer of the rat main olfactory bulb. *Neurosci Res* 23:73-88.
- Kriegstein A, Alvarez-Buylla A (2009) The glial nature of embryonic and adult neural stem cells. *Annu Rev Neurosci* 32:149-84.:149-184.
- Kriegstein AR, Noctor SC (2004) Patterns of neuronal migration in the embryonic cortex. *Trends Neurosci* 27:392-399.
- Kronenberg G, Reuter K, Steiner B, Brandt MD, Jessberger S, Yamaguchi M, Kempermann G (2003) Subpopulations of proliferating cells of the adult hippocampus respond differently to physiologic neurogenic stimuli. *J Comp Neurol* 467:455-463.
- Kruidering M, Schouten T, Evan GI, Vreugdenhil E (2001) Caspase-mediated cleavage of the Ca<sup>2+</sup>/calmodulin-dependent protein kinase-like kinase facilitates neuronal apoptosis. *Journal of Biological Chemistry* 276:38417-38425.
- Kuhn HG, Biehl M, Wilhelm D, Li M, Friedlander RM, Winkler J (2005) Increased generation of granule cells in adult Bcl-2-overexpressing mice: a role for cell death during continued hippocampal neurogenesis. *Eur J Neurosci* 22:1907-1915.
- Kuhn HG, Dickinson-Anson H, Gage FH (1996) Neurogenesis in the dentate gyrus of the adult rat: Age-related decrease of neuronal progenitor proliferation. *Journal of Neuroscience* 16:2027-2033.
- Lagace DC, Benavides DR, Kansy JW, Mapelli M, Greengard P, Bibb JA, Eisch AJ (2008) Cdk5 is essential for adult hippocampal neurogenesis. *Proc Natl Acad Sci U S A* 105:18567-18571.
- Lancaster MA, Knoblich JA (2012) Spindle orientation in mammalian cerebral cortical development. *Curr Opin Neurobiol* 22:737-746.
- Laplagne DA, Esposito MS, Piatti VC, Morgenstern NA, Zhao C, van PH, Gage FH, Schinder AF (2006) Functional convergence of neurons generated in the developing and adult hippocampus. *PLoS Biol* 4:e409.
- Latchney SE, Hein AM, O'Banion MK, Cicco-Bloom E, Opanashuk LA (2013) Deletion or activation of the aryl hydrocarbon receptor alters adult hippocampal neurogenesis and contextual fear memory. *J Neurochem* 125:430-445.
- Lau BW, Yau SY, So KF (2011) Reproduction: a new venue for studying function of adult neurogenesis? *Cell Transplant* 20:21-35.
- Lazarini F, Lledo PM (2010) Is adult neurogenesis essential for olfaction? *Trends Neurosci*.
- Leak RK, Moore RY (2001) Topographic organization of suprachiasmatic nucleus projection neurons. *Journal of Comparative Neurology* 433:312-334.
- Lee DA, Bedont JL, Pak T, Wang H, Song J, Miranda-Angulo A, Takiar V, Charubhumi V, Balordi F, Takebayashi H, Aja S, Ford E, Fishell G, Blackshaw S (2012) Tanycytes of the hypothalamic median eminence form a diet-responsive neurogenic niche. *Nat Neurosci* 15:700-702.

## References

- Lee DA, Blackshaw S (2012) Functional implications of hypothalamic neurogenesis in the adult mammalian brain. *Int J Dev Neurosci* 30:615-621.
- Lee HS, Lim BV, Jang MH, Shin MC, Lee TH, Kim YP, Shin HS, Cho SY, Kim H, Shin MS, Kim EH, Kim CJ (2002) Hypothermia inhibits cell proliferation and nitric oxide synthase expression in rats. *Neuroscience Letters* 329:53-56.
- Lehmann ML, Brachman RA, Martinowich K, Schloesser RJ, Herkenham M (2013) Glucocorticoids orchestrate divergent effects on mood through adult neurogenesis. *J Neurosci* 33:2961-2972.
- Li J, Tang Y, Cai D (2012) IKKbeta/NF-kappaB disrupts adult hypothalamic neural stem cells to mediate a neurodegenerative mechanism of dietary obesity and pre-diabetes. *Nat Cell Biol* 14:999-1012.
- Li Y, Luikart BW, Birnbaum S, Chen J, Kwon CH, Kernie SG, Bassel-Duby R, Parada LF (2008) TrkB regulates hippocampal neurogenesis and governs sensitivity to antidepressant treatment. *Neuron* 59:399-412.
- Li YF, Zhang YZ, Liu YQ, Wang HL, Yuan L, Luo ZP (2004) Moclobemide up-regulates proliferation of hippocampal progenitor cells in chronically stressed mice. *Acta Pharmacologica Sinica* 25:1408-1412.
- Lightman SL, Wiles CC, Atkinson HC, Henley DE, Russell GM, Leendertz JA, McKenna MA, Spiga F, Wood SA, Conway-Campbell BL (2008) The significance of glucocorticoid pulsatility. *European Journal of Pharmacology* 583:255-262.
- Lim DA, Huang YC, Alvarez-Buylla A (2008) Adult Subventricular Zone and Olfactory Bulb Neurogenesis. In: *Adult Neurogenesis* (Gage F, Kempermann G, Song H, eds), pp 175-206. New York: Cold Spring Harbor Laboratory Press.
- Lin PT, Gleeson JG, Corbo JC, Flanagan L, Walsh CA (2000) DCAMKL1 encodes a protein kinase with homology to doublecortin that regulates microtubule polymerization. *J Neurosci* 20:9152-9161.
- Lister RG (1990) Ethologically-based animal models of anxiety disorders. *Pharmacol Ther* 46:321-340.
- Liu Y, Chirino AJ, Misulovin Z, Leteux C, Feizi T, Nussenzweig MC, Bjorkman PJ (2000) Crystal structure of the cysteine-rich domain of mannose receptor complexed with a sulfated carbohydrate ligand. *J Exp Med* 191:1105-1116.
- Liu YW, Curtis MA, Gibbons HM, Mee EW, Bergin PS, Teoh HH, Connor B, Dragunow M, Faull RL (2008) Doublecortin expression in the normal and epileptic adult human brain. *Eur J Neurosci* 28:2254-2265.
- Livak KJ, Schmittgen TD (2001) Analysis of relative gene expression data using real-time quantitative PCR and the 2(-Delta Delta C(T)) Method. *Methods* 25:402-408.
- Lledo PM, Alonso M, Grubb MS (2006) Adult neurogenesis and functional plasticity in neuronal circuits. *Nature Reviews Neuroscience* 7:179-193.
- Lledo PM, Saghatelian A (2005) Integrating new neurons into the adult olfactory bulb: joining the network, life-death decisions, and the effects of sensory experience. *Trends Neurosci* 28:248-254.
- Lledo P-M (2008) Adult neurogenesis in the olfactory bulb. In: *Adult Neurogenesis* (Gage FH, Kempermann G, Song H, eds), pp 425-444. New York: Cold Spring Harbor Laboratory Press.
- Lucassen PJ, Meerlo P, Naylor AS, Van Dam AM, Dayer AG, Fuchs E, Oomen CA, Czeh B (2010a) Regulation of adult neurogenesis by stress, sleep disruption, exercise and inflammation: Implications for depression and antidepressant action. *European Neuropsychopharmacology* 20:1-17.
- Lucassen PJ, Stumpel MW, Wang Q, Aronica E (2010b) Decreased numbers of progenitor cells but no response to antidepressant drugs in the hippocampus of elderly depressed patients. *Neuropharmacology* 58:940-949.
- Luzzati F, De MS, Fasolo A, Peretto P (2006) Neurogenesis in the caudate nucleus of the adult rabbit. *J Neurosci* 26:609-621.

- Machado DG, Cunha MP, Neis VB, Balen GO, Colla AR, Grando J, Brocardo PS, Bettio LE, Dalmarco JB, Rial D, Prediger RD, Pizzolatti MG, Rodrigues AL (2012) *Rosmarinus officinalis* L. hydroalcoholic extract, similar to fluoxetine, reverses depressive-like behavior without altering learning deficit in olfactory bulbectomized mice. *J Ethnopharmacol* 143:158-169.
- MacQueen GM, Campbell S, McEwen BS, Macdonald K, Amano S, Joffe RT, Nahmias C, Young LT (2003) Course of illness, hippocampal function, and hippocampal volume in major depression. *Proceedings of the National Academy of Sciences of the United States of America* 100:1387-1392.
- Mak GK, Enwere EK, Gregg C, Pakarainen T, Poutanen M, Huhtaniemi I, Weiss S (2007) Male pheromone-stimulated neurogenesis in the adult female brain: possible role in mating behavior. *Nat Neurosci* 10:1003-1011.
- Mak GK, Weiss S (2010) Paternal recognition of adult offspring mediated by newly generated CNS neurons. *Nat Neurosci* 13:753-758.
- Malatesta P, Appolloni I, Calzolari F (2008) Radial glia and neural stem cells. *Cell Tissue Res* 331:165-178.
- Malatesta P, Hack MA, Hartfuss E, Kettenmann H, Klinkert W, Kirchhoff F, Gotz M (2003) Neuronal or glial progeny: Regional differences in radial glia fate. *Neuron* 37:751-764.
- Malberg JE, Duman RS (2003) Cell proliferation in adult hippocampus is decreased by inescapable stress: Reversal by fluoxetine treatment. *Neuropsychopharmacology* 28:1562-1571.
- Malberg JE, Eisch AJ, Nestler EJ, Duman RS (2000) Chronic antidepressant treatment increases neurogenesis in adult rat hippocampus. *Journal of Neuroscience* 20:9104-9110.
- Marin O, Rubenstein JL (2003) Cell migration in the forebrain. *Annu Rev Neurosci* 26:441-483.
- Marin-Burgin A, Schinder AF (2012) Requirement of adult-born neurons for hippocampus-dependent learning. *Behav Brain Res* 227:391-399.
- Martinez-Canabal A, Akers KG, Josselyn SA, Frankland PW (2013) Age-dependent effects of hippocampal neurogenesis suppression on spatial learning. *Hippocampus* 23:66-74.
- Matsuzaki K, Katakura M, Hara T, Li G, Hashimoto M, Shido O (2009) Proliferation of neuronal progenitor cells and neuronal differentiation in the hypothalamus are enhanced in heat-acclimated rats. *Pflugers Arch* 458:661-673.
- McEwen BS (2007) Physiology and neurobiology of stress and adaptation: Central role of the brain. *Physiological Reviews* 87:873-904.
- McEwen BS (1998) Stress, adaptation, and disease - Allostasis and allostatic load. *Neuroimmunomodulation* 840:33-44.
- McEwen BS, Gianaros PJ (2011) Stress- and Allostasis-Induced Brain Plasticity. *Annual Review of Medicine*, Vol 62, 2011 62:431-445.
- Meijer JH, Michel S, vanderLeest HT, Rohling JHT (2010) Daily and seasonal adaptation of the circadian clock requires plasticity of the SCN neuronal network. *European Journal of Neuroscience* 32:2143-2151.
- Merz K, Lie DC (2013) Evidence that Doublecortin is dispensable for the development of adult born neurons in mice. *PLoS One* 8:e62693.
- Meshi D, Drew MR, Saxe M, Ansorge MS, David D, Santarelli L, Malapani C, Moore H, Hen R (2006) Hippocampal neurogenesis is not required for behavioral effects of environmental enrichment. *Nature Neuroscience* 9:729-731.

## References

- Meyer G, Gonzalezhernandez T, Carrillopadilla F, Ferrestorres R (1989) Aggregations of Granule Cells in the Basal Forebrain (Islands of Calleja) - Golgi and Cytoarchitectonic Study in Different Mammals, Including Man. *Journal of Comparative Neurology* 284:405-428.
- Millan C, Martinez F, Cortes-Campos C, Lizama I, Yanez MJ, Llanos P, Reinicke K, Rodriguez F, Peruzzo B, Nualart F, Garcia MA (2010) Glial glucokinase expression in adult and post-natal development of the hypothalamic region. *Asn Neuro* 2:135-145.
- Millhouse OE (1987) Granule Cells of the Olfactory Tubercle and the Question of the Islands of Calleja. *Journal of Comparative Neurology* 265:1-24.
- Ming GL, Song HJ (2005) Adult neurogenesis in the mammalian central nervous system. *Annual Review of Neuroscience* 28:223-250.
- Ming GL, Song HJ (2011) Adult Neurogenesis in the Mammalian Brain: Significant Answers and Significant Questions. *Neuron* 70:687-702.
- Mirescu C, Gould E (2006) Stress and adult neurogenesis. *Hippocampus* 16:233-238.
- Mirescu C, Peters JD, Gould E (2004) Early life experience alters response of adult neurogenesis to stress. *Nat Neurosci* 7:841-846.
- Mirescu C, Peters JD, Noiman L, Gould E (2006) Sleep deprivation inhibits adult neurogenesis in the hippocampus by elevating glucocorticoids. *Proc Natl Acad Sci U S A* 103:19170-19175.
- Moore CA, Perderiset M, Francis F, Chelly J, Houdusse A, Milligan RA (2004) Mechanism of microtubule stabilization by doublecortin. *Molecular Cell* 14:833-839.
- Moore CA, Perderiset M, Kappeler C, Kain S, Drummond D, Perkins SJ, Chelly J, Cross R, Houdusse A, Francis F (2006) Distinct roles of doublecortin modulating the microtubule cytoskeleton. *EMBO J* 25:4448-4457.
- Morin LP (2007) SCN organization reconsidered. *Journal of Biological Rhythms* 22:3-13.
- Mullier A, Bouret SG, Prevot V, Dehouck B (2010) Differential Distribution of Tight Junction Proteins Suggests a Role for Tanycytes in Blood-Hypothalamus Barrier Regulation in the Adult Mouse Brain. *Journal of Comparative Neurology* 518:943-962.
- Muramatsu R, Ikegaya Y, Matsuki N, Koyama R (2007) Neonatally born granule cells numerically dominate adult mice dentate gyrus. *Neuroscience* 148:593-598.
- Murata K, Imai M, Nakanishi S, Watanabe D, Pastan I, Kobayashi K, Nihira T, Mochizuki H, Yamada S, Mori K, Yamaguchi M (2011) Compensation of Depleted Neuronal Subsets by New Neurons in a Local Area of the Adult Olfactory Bulb. *J Neurosci* 31:10540-10557.
- Murphy M, Ebling FJ (2011) The role of hypothalamic tri-iodothyronine availability in seasonal regulation of energy balance and body weight. *J Thyroid Res* 2011:387562.
- Nacher J, Crespo C, McEwen BS (2001) Doublecortin expression in the adult rat telencephalon. *Eur J Neurosci* 14:629-644.
- Nadarajah B, Brunstrom JE, Grutzendler J, Wong RO, Pearlman AL (2001) Two modes of radial migration in early development of the cerebral cortex. *Nat Neurosci* 4:143-150.
- Ng KL, Li JD, Cheng MY, Leslie FM, Lee AG, Zhou QY (2005) Dependence of olfactory bulb neurogenesis on prokineticin 2 signaling. *Science* 308:1923-1927.

- Nissant A, Pallotto M (2011) Integration and maturation of newborn neurons in the adult olfactory bulb--from synapses to function. *Eur J Neurosci* 33:1069-1077.
- Noctor SC, Flint AC, Weissman TA, Dammerman RS, Kriegstein AR (2001) Neurons derived from radial glial cells establish radial units in neocortex. *Nature* 409:714-720.
- Noctor SC, Martinez-Cerdeno V, Kriegstein AR (2008) Distinct behaviors of neural stem and progenitor cells underlie cortical neurogenesis. *J Comp Neurol* 508:28-44.
- Ohmae S, Takemoto-Kimura S, Okamura M, chi-Morishima A, Nonaka M, Fuse T, Kida S, Tanji M, Furuyashiki T, Arakawa Y, Narumiya S, Okuno H, Bito H (2006) Molecular identification and characterization of a family of kinases with homology to Ca<sup>2+</sup>/calmodulin-dependent protein kinases I/IV. *J Biol Chem* 281:20427-20439.
- Oomen CA, Mayer JL, de Kloet ER, Joels M, Lucassen PJ (2007) Brief treatment with the glucocorticoid receptor antagonist mifepristone normalizes the reduction in neurogenesis after chronic stress. *Eur J Neurosci* 26:3395-3401.
- Oomen CA, Soeters H, Audureau N, Vermunt L, van Hasselt FN, Manders EM, Joels M, Lucassen PJ, Krugers H (2010) Severe early life stress hampers spatial learning and neurogenesis, but improves hippocampal synaptic plasticity and emotional learning under high-stress conditions in adulthood. *J Neurosci* 30:6635-6645.
- Out C, Hageman J, Bloks VW, Gerrits H, Sollewijn G, Bos T, Havinga R, Smit MJ, Kuipers F, Groen AK (2011) Liver receptor homolog-1 is critical for adequate up-regulation of Cyp7a1 gene transcription and bile salt synthesis during bile salt sequestration. *Hepatology* 53:2075-2085.
- Pan YW, Chan GC, Kuo CT, Storm DR, Xia Z (2012) Inhibition of adult neurogenesis by inducible and targeted deletion of ERK5 mitogen-activated protein kinase specifically in adult neurogenic regions impairs contextual fear extinction and remote fear memory. *J Neurosci* 32:6444-6455.
- Parrish-Aungst S, Shipley MT, Erdelyi F, Szabo G, Puche AC (2007) Quantitative analysis of neuronal diversity in the mouse olfactory bulb. *Journal of Comparative Neurology* 501:825-836.
- Paxinos G, Franklin KBJ (2001) *The Mouse Brain in stereotaxic coordinates*. Academic press.
- Pekcec A, Loscher W, Potschka H (2006) Neurogenesis in the adult rat piriform cortex. *Neuroreport* 17:571-574.
- Pencea V, Bingaman KD, Wiegand SJ, Luskin MB (2001) Infusion of brain-derived neurotrophic factor into the lateral ventricle of the adult rat leads to new neurons in the parenchyma of the striatum, septum, thalamus, and hypothalamus. *J Neurosci* 21:6706-6717.
- Perez-Martin M, Cifuentes M, Grondona JM, Lopez-Avalos MD, Gomez-Pinedo U, Garcia-Verdugo JM, Fernandez-Llebrez P (2010) IGF-I stimulates neurogenesis in the hypothalamus of adult rats. *Eur J Neurosci* 31:1533-1548.
- Petrik D, Lagace DC, Eisch AJ (2012) The neurogenesis hypothesis of affective and anxiety disorders: are we mistaking the scaffolding for the building? *Neuropharmacology* 62:21-34.
- Pham K, Nacher J, Hof PR, Mcewen BS (2003) Repeated restraint stress suppresses neurogenesis and induces biphase PSA-NCAM expression in the adult rat dentate gyrus. *European Journal of Neuroscience* 17:879-886.
- Phillips RG, Ledoux JE (1992) Differential contribution of amygdala and hippocampus to cued and contextual fear conditioning. *Behav Neurosci* 106:274-285.
- Pickard B (2011) Progress in defining the biological causes of schizophrenia. *Expert Reviews in Molecular Medicine* 13.

## References

- Plumpe T, Ehninger D, Steiner B, Klempin F, Jessberger S, Brandt M, Romer B, Rodriguez GR, Kronenberg G, Kempermann G (2006) Variability of doublecortin-associated dendrite maturation in adult hippocampal neurogenesis is independent of the regulation of precursor cell proliferation. *BMC Neurosci* 7:77.
- Pramparo T, Youn YH, Yingling J, Hirotsune S, Wynshaw-Boris A (2010) Novel embryonic neuronal migration and proliferation defects in Dcx mutant mice are exacerbated by Lis1 reduction. *J Neurosci* 30:3002-3012.
- Prevot V (2002) Glial-neuronal-endothelial interactions are involved in the control of GnRH secretion. *Journal of Neuroendocrinology* 14:247-255.
- Prosser RA, Rutishauser U, Ungers G, Fedorkova L, Glass JD (2003) Intrinsic role of polysialylated neural cell adhesion molecule in photic phase resetting of the mammalian circadian clock. *Journal of Neuroscience* 23:652-658.
- Raber J, Rola R, LeFevour A, Morhardt D, Curley J, Mizumatsu S, VandenBerg SR, Fike JR (2004) Radiation-induced cognitive impairments are associated with changes in indicators of hippocampal neurogenesis. *Radiat Res* 162:39-47.
- Rakic P (2002) Adult neurogenesis in mammals: An identity crisis. *Journal of Neuroscience* 22:614-618.
- Rakic P (2006) No more cortical neurons for you. *Science* 313:928-929.
- Rami A, Brehier A, Thomasset M, Rabie A (1987) Cholecalciferol (28-Kda Calcium-Binding Protein) in the Rat Hippocampus - Development in Normal Animals and in Altered Thyroid States - An Immunocytochemical Study. *Developmental Biology* 124:228-238.
- Rao MS, Shetty AK (2004) Efficacy of doublecortin as a marker to analyse the absolute number and dendritic growth of newly generated neurons in the adult dentate gyrus. *European Journal of Neuroscience* 19:234-246.
- Reif A, Fritzen S, Finger M, Strobel A, Lauer M, Schmitt A, Lesch KP (2006) Neural stem cell proliferation is decreased in schizophrenia, but not in depression. *Molecular Psychiatry* 11:514-522.
- Reiner O, Coquelle FM, Peter B, Levy T, Kaplan A, Sapir T, Orr I, Barkai N, Eichele G, Bergmann S (2006) The evolving doublecortin (DCX) superfamily. *Bmc Genomics* 7.
- Reul JMHM, deKloet ER (1985) 2 Receptor Systems for Corticosterone in Rat-Brain - Microdistribution and Differential Occupation. *Endocrinology* 117:2505-2511.
- Rhodes JS, van Praag H, Jeffrey S, Girard I, Mitchell GS, Garland T, Gage FH (2003) Exercise increases hippocampal neurogenesis to high levels but does not improve spatial learning in mice bred for increased voluntary wheel running. *Behavioral Neuroscience* 117:1006-1016.
- Rodriguez EM, Blazquez JL, Guerra M (2010) The design of barriers in the hypothalamus allows the median eminence and the arcuate nucleus to enjoy private milieus: The former opens to the portal blood and the latter to the cerebrospinal fluid. *Peptides* 31:757-776.
- Rodriguez EM, Blazquez JL, Pastor FE, Pelaez B, Pena P, Peruzzo B, Amat P (2005) Hypothalamic tanycytes: a key component of brain-endocrine interaction. *Int Rev Cytol* 247:89-164.:89-164.
- Ruijter JM, Ramakers C, Hoogaars WM, Karlen Y, Bakker O, van den Hoff MJ, Moorman AF (2009) Amplification efficiency: linking baseline and bias in the analysis of quantitative PCR data. *Nucleic Acids Res* 37:e45.
- Saaltink DJ, Havik B, Verissimo CS, Lucassen PJ, Vreugdenhil E (2012) Doublecortin and doublecortin-like are expressed in overlapping and non-overlapping neuronal cell population: Implications for neurogenesis. *J Comp Neurol* 520:2805-2823.

- Saghatelyan A, de CA, Schachner M, Lledo PM (2004) Tenascin-R mediates activity-dependent recruitment of neuroblasts in the adult mouse forebrain. *Nat Neurosci* 7:347-356.
- Sah A, Schmuckermair C, Sartori SB, Gaburro S, Kandasamy M, Irschick R, Klimaschewski L, Landgraf R, Aigner L, Singewald N (2012) Anxiety- rather than depression-like behavior is associated with adult neurogenesis in a female mouse model of higher trait anxiety- and comorbid depression-like behavior. *Transl Psychiatry* 2:e171.
- Sahay A, Hen R (2007) Adult hippocampal neurogenesis in depression. *Nat Neurosci* 10:1110-1115.
- Sahay A, Scobie KN, Hill AS, O'Carroll CM, Kheirbek MA, Burghardt NS, Fenton AA, Dranovsky A, Hen R (2011a) Increasing adult hippocampal neurogenesis is sufficient to improve pattern separation. *Nature* 472:466-U539.
- Sahay A, Wilson DA, Hen R (2011b) Pattern Separation: A Common Function for New Neurons in Hippocampus and Olfactory Bulb. *Neuron* 70:582-588.
- Samuels BA, Hen R (2011) Neurogenesis and affective disorders. *Eur J Neurosci* 33:1152-1159.
- Sanai N, Berger MS, Garcia-Verdugo JM, varez-Buylla A (2007) Comment on "Human neuroblasts migrate to the olfactory bulb via a lateral ventricular extension". *Science* 318:393.
- Sanchez E, Vargas MA, Singru PS, Pascual I, Romero F, Fekete C, Charli JL, Lechan RM (2009) Tanycyte Pyroglutamylation Contributes to Regulation of the Hypothalamic-Pituitary-Thyroid Axis through Glial-Axonal Associations in the Median Eminence. *Endocrinology* 150:2283-2291.
- Sandeman R, Sandeman D (2000) "Impoverished" and "enriched" living conditions influence the proliferation and survival of neurons in crayfish brain. *Journal of Neurobiology* 45:215-226.
- Santarelli L, Saxe M, Gross C, Surget A, Battaglia F, Dulawa S, Weisstaub N, Lee J, Duman R, Arancio O, Belzung C, Hen R (2003) Requirement of hippocampal neurogenesis for the behavioral effects of antidepressants. *Science* 301:805-809.
- Sapolsky RM (2004) Is impaired neurogenesis relevant to the affective symptoms of depression? *Biol Psychiatry* 56:137-139.
- Sapolsky RM (2000) Glucocorticoids and hippocampal atrophy in neuropsychiatric disorders. *Archives of General Psychiatry* 57:925-935.
- Sapolsky RM (2001) Depression, antidepressants, and the shrinking hippocampus. *Proceedings of the National Academy of Sciences of the United States of America* 98:12320-12322.
- Saxe MD, Battaglia F, Wang JW, Malleret G, David DJ, Monckton JE, Garcia ADR, Sofroniew MV, Kandel ER, Santarelli L, Hen R, Drew MR (2006) Ablation of hippocampal neurogenesis impairs contextual fear conditioning and synaptic plasticity in the dentate gyrus. *Proceedings of the National Academy of Sciences of the United States of America* 103:17501-17506.
- Schaar BT, Kinoshita K, McConnell SK (2004) Doublecortin microtubule affinity is regulated by a balance of kinase and phosphatase activity at the leading edge of migrating neurons. *Neuron* 41:203-213.
- Schenk GJ, Engels B, Zhang YP, Fitzsimons CP, Schouten T, Kruidering M, de Kloet ER, Vreugdenhil E (2007) A potential role for calcium / calmodulin-dependent protein kinase-related peptide in neuronal apoptosis: in vivo and in vitro evidence. *Eur J Neurosci* 26:3411-3420.
- Schoenfeld TJ, Gould E (2012) Stress, stress hormones, and adult neurogenesis. *Exp Neurol* 233:12-21.

## References

- Schwartz WJ, Reppert SM (1985) Neural regulation of the circadian vasopressin rhythm in cerebrospinal fluid: a pre-eminent role for the suprachiasmatic nuclei. *J Neurosci* 5:2771-2778.
- Scott JP (1966) Agonistic behavior of mice and rats: a review. *Am Zool* 6:683-701.
- Scotto LS, Strambi C, Strambi A, Charpin P, Augier R, Aouane A, Cayre M (2000) Influence of environmental stimulation on neurogenesis in the adult insect brain. *J Neurobiol* 45:162-171.
- Seibler J, Kleinridders A, Kuter-Luks B, Niehaves S, Bruning JC, Schwenk F (2007) Reversible gene knockdown in mice using a tight, inducible shRNA expression system. *Nucleic Acids Res* 35:e54.
- Seri B, Garcia-Verdugo JM, Collado-Morente L, McEwen BS, varez-Buylla A (2004) Cell types, lineage, and architecture of the germinal zone in the adult dentate gyrus. *J Comp Neurol* 478:359-378.
- Seri B, Garcia-Verdugo JM, McEwen BS, varez-Buylla A (2001) Astrocytes give rise to new neurons in the adult mammalian hippocampus. *J Neurosci* 21:7153-7160.
- Shapiro LA, Ng K, Zhou QY, Ribak CE (2009) Subventricular zone-derived, newly generated neurons populate several olfactory and limbic forebrain regions. *Epilepsy & Behavior* 14:74-80.
- Sheline YI, Sanghavi M, Mintun MA, Gado MH (1999) Depression duration but not age predicts hippocampal volume loss in medically healthy women with recurrent major depression. *Journal of Neuroscience* 19:5034-5043.
- Sheline YI, Wang PW, Gado MH, Csernansky JG, Vannier MW (1996) Hippocampal atrophy in recurrent major depression. *Proceedings of the National Academy of Sciences of the United States of America* 93:3908-3913.
- Shen HM, Glass JD, Seki T, Watanabe M (1999) Ultrastructural analysis of polysialylated neural cell adhesion molecule in the suprachiasmatic nuclei of the adult mouse. *Anatomical Record* 256:448-457.
- Shen HM, Watanabe M, Tomasiewicz H, Rutishauser U, Magnuson T, Glass JD (1997) Role of neural cell adhesion molecule and polysialic acid in mouse circadian clock function. *Journal of Neuroscience* 17:5221-5229.
- Shin E, Kashiwagi Y, Kuriu T, Iwasaki H, Tanaka T, Koizumi H, Gleeson JG, Okabe S (2013) Doublecortin-like kinase enhances dendritic remodelling and negatively regulates synapse maturation. *Nat Commun* 4:1440.
- Shors TJ, Townsend DA, Zhao M, Kozorovitskiy Y, Gould E (2002) Neurogenesis may relate to some but not all types of hippocampal-dependent learning. *Hippocampus* 12:578-584.
- Shu TZ, Tseng HC, Sapir T, Stern P, Zhou Y, Sanada K, Fischer A, Coquelle FM, Reiner O, Tsai LH (2006) Doublecortin-like kinase controls neurogenesis by regulating mitotic spindles and M phase progression. *Neuron* 49:25-39.
- Sidibe A, Mullier A, Chen P, Baroncini M, Boutin JA, Delagrèze P, Prevot V, Jockers R (2010) Expression of the orphan GPR50 protein in rodent and human dorsomedial hypothalamus, tanycytes and median eminence. *J Pineal Res* 48:263-269.
- Silverman MA, Benard O, Jaaro H, Rattner A, Citri Y, Seger R (1999) CPG16, a novel protein serine/threonine kinase downstream of cAMP-dependent protein kinase. *J Biol Chem* 274:2631-2636.
- Snyder JS, Soumier A, Brewer M, Pickel J, Cameron HA (2011) Adult hippocampal neurogenesis buffers stress responses and depressive behaviour. *Nature* 476:458-461.
- Sossey-Alaoui K, Hartung AJ, Guerrini R, Manchester DK, Posar A, Puche-Mira A, Andermann E, Dobyns WB, Srivastava AK (1998) Human doublecortin (DCX) and the homologous gene in mouse encode a putative Ca<sup>2+</sup>-dependent signaling protein which is mutated in human X-linked neuronal migration defects. *Hum Mol Genet* 7:1327-1332.

- Sossey-Alaoui K, Srivastava AK (1999) DCAMK1, a brain-specific transmembrane protein on 13q12.3 that is similar to doublecortin (DCX). *Genomics* 56:121-126.
- Sousa-Ferreira L, Alvaro AR, Aveleira C, Santana M, Brandao I, Kugler S, de Almeida LP, Cavadas C (2011) Proliferative hypothalamic neurospheres express NPY, AGRP, POMC, CART and Orexin-A and differentiate to functional neurons. *PLoS One* 6:e19745.
- Steffens DC, Byrum CE, McQuoid DR, Greenberg DL, Payne ME, Blitchington TF, MacFall JR, Krishnan KRR (2000) Hippocampal volume in geriatric depression. *Biological Psychiatry* 48:301-309.
- Steiner B, Klempin F, Wang L, Kott M, Kettenmann H, Kempermann G (2006) Type-2 cells as link between glial and neuronal lineage in adult hippocampal neurogenesis. *Glia* 54:805-814.
- Steinsapir J, Bianco AC, Buettner C, Harney J, Larsen PR (2000) Substrate-induced down-regulation of human type 2 deiodinase (hD2) is mediated through proteasomal degradation and requires interaction with the enzyme's active center. *Endocrinology* 141:1127-1135.
- Stockmeier CA, Mahajan GJ, Konick LC, Overholser JC, Jurjus GJ, Meltzer HY, Uylings HBM, Friedman L, Rajkowska G (2004) Cellular changes in the postmortem hippocampus in major depression. *Biological Psychiatry* 56:640-650.
- Stranahan AM, Khalil D, Gould E (2006) Social isolation delays the positive effects of running on adult neurogenesis. *Nature Neuroscience* 9:526-533.
- Surget A, Saxe M, Leman S, Ibarguen-Vargas Y, Chalon S, Griebel G, Hen R, Belzung C (2008) Drug-dependent requirement of hippocampal neurogenesis in a model of depression and of antidepressant reversal. *Biological Psychiatry* 64:293-301.
- Tanaka T, Koizumi H, Gleeson JG (2006) The Doublecortin and Doublecortin-like kinase 1 genes cooperate in murine hippocampal development. *Cerebral Cortex* 16:169-173.
- Tanapat P, Hastings NB, Rydel TA, Galea LAM, Gould E (2001) Exposure to fox odor inhibits cell proliferation in the hippocampus of adult rats via an adrenal hormone-dependent mechanism. *Journal of Comparative Neurology* 437:496-504.
- Taupin P (2007) BrdU immunohistochemistry for studying adult neurogenesis: paradigms, pitfalls, limitations, and validation. *Brain Res Rev* 53:198-214.
- Taupin P, Gage FH (2002) Adult neurogenesis and neural stem cells of the central nervous system in mammals. *J Neurosci Res* 69:745-749.
- Toni N, Laplagne DA, Zhao C, Lombardi G, Ribak CE, Gage FH, Schinder AF (2008) Neurons born in the adult dentate gyrus form functional synapses with target cells. *Nat Neurosci* 11:901-907.
- Toni N, Sultan S (2011) Synapse formation on adult-born hippocampal neurons. *Eur J Neurosci* 33:1062-1068.
- Toni N, Teng EM, Bushong EA, Aimone JB, Zhao C, Consiglio A, van PH, Martone ME, Ellisman MH, Gage FH (2007) Synapse formation on neurons born in the adult hippocampus. *Nat Neurosci* 10:727-734.
- Treves A, Tashiro A, Witter MP, Moser EI (2008) What is the mammalian dentate gyrus good for? *Neuroscience* 154:1155-1172.
- Tronel S, Belnoue L, Grosjean N, Revest JM, Piazza PV, Koehl M, Abrous DN (2012) Adult-born neurons are necessary for extended contextual discrimination. *Hippocampus* 22:292-298.

## References

- Tu HM, Kim SW, Salvatore D, Bartha T, Legradi G, Larsen PR, Lechan RM (1997) Regional distribution of type 2 thyroxine deiodinase messenger ribonucleic acid in rat hypothalamus and pituitary and its regulation by thyroid hormone. *Endocrinology* 138:3359-3368.
- Tuy FP, Saillour Y, Kappeler C, Chelly J, Francis F (2008) Alternative transcripts of *Dclk1* and *Dclk2* and their expression in doublecortin knockout mice. *Dev Neurosci* 30:171-186.
- Ubeda-Banon I, Novejarque A, Mohedano-Moriano A, Pro-Sistiaga P, Insausti R, Martinez-Garcia F, Lanuza E, Martinez-Marcos A (2008) Vomeronasal inputs to the rodent ventral striatum. *Brain Research Bulletin* 75:467-473.
- Urbach A, Robakiewicz I, Baum E, Kaczmarek L, Witte OW, Filipkowski RK (2013) Cyclin D2 knockout mice with depleted adult neurogenesis learn Barnes maze task. *Behav Neurosci* 127:1-8.
- van Hooijdonk LW, Ichwan M, Dijkmans TF, Schouten TG, de Backer MW, Adan RA, Verbeek FJ, Vreugdenhil E, Fitzsimons CP (2009) Lentivirus-mediated transgene delivery to the hippocampus reveals sub-field specific differences in expression. *BMC Neurosci* 10:2.
- van Praag H, Christie BR, Sejnowski TJ, Gage FH (1999a) Running enhances neurogenesis, learning, and long-term potentiation in mice. *Proceedings of the National Academy of Sciences of the United States of America* 96:13427-13431.
- van Praag H, Kempermann G, Gage FH (1999b) Running increases cell proliferation and neurogenesis in the adult mouse dentate gyrus. *Nature Neuroscience* 2:266-270.
- van Praag H, Schinder AF, Christie BR, Toni N, Palmer TD, Gage FH (2002) Functional neurogenesis in the adult hippocampus. *Nature* 415:1030-1034.
- van Rijzingen I, Gispen WH, Spruijt BM (1995) Olfactory bulbectomy temporarily impairs Morris maze performance: an ACTH(4-9) analog accelerates return of function. *Physiol Behav* 58:147-152.
- Varea E, Castillo-Gomez E, Gomez-Climent MA, Guirado R, Blasco-Ibanez JM, Crespo C, Martinez-Guijarro FJ, Nacher J (2009) Differential evolution of PSA-NCAM expression during aging of the rat telencephalon. *Neurobiology of Aging* 30:808-818.
- Veenema AH, de Kloet ER, de Wilde MC, Roelofs AJ, Kawata M, Buwalda B, Neumann ID, Koolhaas JM, Lucassen PJ (2007) Differential effects of stress on adult hippocampal cell proliferation in low and high aggressive mice. *J Neuroendocrinol* 19:489-498.
- Verissimo CS, Elands R, Cheng S, Saaltink DJ, Ter Horst JP, Alme MN, Pont C, van de WB, Havik B, Fitzsimons CP, Vreugdenhil E (2013) Silencing of Doublecortin-Like (DCL) Results in Decreased Mitochondrial Activity and Delayed Neuroblastoma Tumor Growth. *PLoS One* 8:e75752.
- Verissimo CS, Molenaar JJ, Meerman J, Puigvert JC, Lamers F, Koster J, Danen EHJ, van de Water B, Versteeg R, Fitzsimons CP, Vreugdenhil E (2010a) Silencing of the microtubule-associated proteins doublecortin-like and doublecortin-like kinase-long induces apoptosis in neuroblastoma cells. *Endocrine-Related Cancer* 17:399-414.
- Verissimo CS, Molenaar JJ, Meerman J, Puigvert JC, Lamers F, van Kuik-Romeijn P, Danen EHJ, van de Water B, Versteeg R, Fitzsimons CP, Vreugdenhil E (2010b) Exploring A New Therapy for Neuroblastoma: Silencing of Doublecortin-Like Kinase Using Rna-Interference. *Neuro-Oncology* 12:64.
- Vollmayr B, Simonis C, Weber S, Gass P, Henn F (2003) Reduced cell proliferation in the dentate gyrus is not correlated with the development of learned helplessness. *Biological Psychiatry* 54:1035-1040.

- Vreugdenhil E, Datson N, Engels B, de Jong J, van Koningsbruggen S, Schaaf M, de Kloet ER (1999) Kainate-elicited seizures induce mRNA encoding a CaMK-related peptide: A putative modulator of kinase activity in rat hippocampus. *Journal of Neurobiology* 39:41-50.
- Vreugdenhil E, Engels B, Middelburg R, van Koningsbruggen S, Knol J, Veldhuisen B, de Kloet ER (2001) Multiple transcripts generated by the DCAMKL gene are expressed in the rat hippocampus. *Molecular Brain Research* 94:67-74.
- Vreugdenhil E, Kolk SM, Boekhoorn K, Fitzsimons CP, Schaaf M, Schouten T, Sarabdjitsingh A, Sibug R, Lucassen PJ (2007) Doublecortin-like, a microtubule-associated protein expressed in radial glia, is crucial for neuronal precursor division and radial process stability. *European Journal of Neuroscience* 25:635-648.
- Waclaw RR, Allen ZJ, Bell SM, Erdelyi F, Szabo G, Potter SS, Campbell K (2006) The zinc finger transcription factor Sp8 regulates the generation and diversity of olfactory bulb interneurons. *Neuron* 49:503-516.
- Walker TL, Yasuda T, Adams DJ, Bartlett PF (2007) The doublecortin-expressing population in the developing and adult brain contains multipotential precursors in addition to neuronal-lineage cells. *Journal of Neuroscience* 27:3734-3742.
- Wang C, Liu F, Liu YY, Zhao CH, You Y, Wang L, Zhang J, Wei B, Ma T, Zhang Q, Zhang Y, Chen R, Song H, Yang Z (2011) Identification and characterization of neuroblasts in the subventricular zone and rostral migratory stream of the adult human brain. *Cell Res* 21:1534-1550.
- Wang JW, David DJ, Monckton JE, Battaglia F, Hen R (2008) Chronic fluoxetine stimulates maturation and synaptic plasticity of adult-born hippocampal granule cells. *J Neurosci* 28:1374-1384.
- Wang LP, Kempermann G, Kettenmann H (2005) A subpopulation of precursor cells in the mouse dentate gyrus receives synaptic GABAergic input. *Mol Cell Neurosci* 29:181-189.
- Warner-Schmidt JL, Duman RS (2006) Hippocampal neurogenesis: opposing effects of stress and antidepressant treatment. *Hippocampus* 16:239-249.
- Watanabe Y, Gould E, McEwen BS (1992) Stress Induces Atrophy of Apical Dendrites of Hippocampal Ca3 Pyramidal Neurons. *Brain Research* 588:341-345.
- Weimer JM, Anton ES (2006) Doubling up on microtubule stabilizers: Synergistic functions of doublecortin-like kinase and doublecortin in the developing cerebral cortex. *Neuron* 49:3-4.
- Welsh DK, Takahashi JS, Kay SA (2010) Suprachiasmatic Nucleus: Cell Autonomy and Network Properties. *Annual Review of Physiology* 72:551-577.
- Werner L, Muller-Fielitz H, Ritzel M, Werner T, Rossner M, Schwaninger M (2012) Involvement of doublecortin-expressing cells in the arcuate nucleus in body weight regulation. *Endocrinology* 153:2655-2664.
- Wibrand K, Messaoudi E, Havik B, Steenslid V, Lovlie R, Steen VM, Bramham CR (2006) Identification of genes co-upregulated with Arc during BDNF-induced long-term potentiation in adult rat dentate gyrus in vivo. *Eur J Neurosci* 23:1501-1511.
- Wichterle H, Garcia-Verdugo JM, varez-Buylla A (1997) Direct evidence for homotypic, glia-independent neuronal migration. *Neuron* 18:779-791.
- Wiersinga WM, Chopra IJ (1982) Radioimmunoassay of thyroxine (T4), 3,5,3'-triiodothyronine (T3), 3,3',5'-triiodothyronine (reverse T3, rT3), and 3,3'-diiodothyronine (T2). *Methods Enzymol* 84:272-303.

## References

- Wilson DA, Best AR, Sullivan RM (2004) Plasticity in the olfactory system: Lessons for the neurobiology of memory. *Neuroscientist* 10:513-524.
- Wiskott L, Rasch MJ, Kempermann G (2006) A functional hypothesis for adult hippocampal neurogenesis: avoidance of catastrophic interference in the dentate gyrus. *Hippocampus* 16:329-343.
- Wojtowicz JM, Kee N (2006) BrdU assay for neurogenesis in rodents. *Nat Protoc* 1:1399-1405.
- Wong EY, Herbert J (2004) The corticoid environment: a determining factor for neural progenitors' survival in the adult hippocampus. *Eur J Neurosci* 20:2491-2498.
- Xu HY, Chen Z, He J, Haimanot S, Li XK, Dyck L, Li XM (2006) Synergetic effects of quetiapine and venlafaxine in preventing the chronic restraint stress-induced decrease in cell proliferation and BDNF expression in rat hippocampus. *Hippocampus* 16:551-559.
- Xu Y, Tamamaki N, Noda T, Kimura K, Itokazu Y, Matsumoto N, Dezawa M, Ide C (2005) Neurogenesis in the ependymal layer of the adult rat 3rd ventricle. *Experimental Neurology* 192:251-264.
- Young EA, Haskett RF, MurphyWeinberg V, Watson SJ, Akil H (1991) Loss of Glucocorticoid Fast Feedback in Depression. *Archives of General Psychiatry* 48:693-699.
- Zhang CL, Zou Y, He W, Gage FH, Evans RM (2008) A role for adult TLX-positive neural stem cells in learning and behaviour. *Nature* 451:1004-1007.
- Zhang J, Giesert F, Kloos K, Vogt Weisenhorn DM, Aigner L, Wurst W, Couillard-Despres S (2010) A powerful transgenic tool for fate mapping and functional analysis of newly generated neurons. *BMC Neurosci* 11:158.
- Zhang XM, Cai Y, Chu Y, Chen EY, Feng JC, Luo XG, Xiong K, Struble RG, Clough RW, Patrylo PR, Kordower JH, Yan XX (2009) Doublecortin-expressing cells persist in the associative cerebral cortex and amygdala in aged nonhuman primates. *Front Neuroanat* 3:17.
- Zhao C, Teng EM, Summers RG, Jr., Ming GL, Gage FH (2006) Distinct morphological stages of dentate granule neuron maturation in the adult mouse hippocampus. *J Neurosci* 26:3-11.
- Zhao M, Janson Lang AM (2009) Bromodeoxyuridine infused into the cerebral ventricle of adult mice labels nigral neurons under physiological conditions--a method to detect newborn nerve cells in regions with a low rate of neurogenesis. *J Neurosci Methods* 184:327-331.
- Zhao M, Momma S, Delfani K, Carlen M, Cassidy RM, Johansson CB, Brismar H, Shupliakov O, Frisen J, Janson AM (2003) Evidence for neurogenesis in the adult mammalian substantia nigra. *Proc Natl Acad Sci U S A* 100:7925-7930.



