

DAFTAR PUSTAKA

- Aarse, J., Herlitze, S., & Manahan-Vaughan, D. (2016). The requirement of BDNF for hippocampal synaptic plasticity is experience-dependent. *Hippocampus*, 26(6), 739–751.
- Abel, T., & Lattal, K. M. (2001). Molecular mechanisms of memory acquisition, consolidation and retrieval. *Current Opinion in Neurobiology*, 11(2), 180–187.
- Aguilar, A., Granados, L., Kemper, T., Debassio, W., Galler, J., & Morgane, P. (1997). Effects of Prenatal Protein Malnutrition on Hippocampal CA1 Pyramidal Cells in Rats of Four Age Groups. *Hippocampus*, 7, 192–203.
- Ahmad, A., Moriguchi, T., & Salem, N. (2002). Decrease in neuron size in docosahexaenoic acid-deficient brain. *Pediatric Neurology*, 26(3), 210–218.
- Aimone, J. B., Li, Y., Lee, S. W., Clemenson, G. D., Deng, W., & Gage, F. H. (2014). Regulation and function of adult neurogenesis: from genes to cognition. *Physiological Reviews*, 94(4), 991–1026.
- Alam, M. J., Kitamura, T., Saitoh, Y., Ohkawa, N., Kondo, T., & Inokuchi, K. (2018). Adult neurogenesis conserves hippocampal memory capacity. *Journal of Neuroscience*, 38(31), 6854–6863.
- Alvin, V. (2009). Spatial Navigation (Water Maze) Tasks in Methods of behavior analysis in neuroscience (Buccafuso Jerry J (ed.)). CRC Press.
- Anderson, M. A., Burda, J. E., Ren, Y., Ao, Y., O'Shea, T. M., Kawaguchi, R., Coppola, G., Khakh, B. S., Deming, T. J., & Sofroniew, M. V. (2016). Astrocyte scar formation AIDS central nervous system axon regeneration. *Nature*, 532(7598), 195–200.
- Arai, Y., Funatsu, N., Numayama-Tsuruta, K., Nomura, T., Nakamura, S., & Osumi, N. (2005). Role of Fabp7, a downstream gene of Pax6, in the maintenance of neuroepithelial cells during early embryonic development of the rat cortex. *Journal of Neuroscience*, 25(42), 9752–9761.
- Avraham, Y., Saidian, M., Burston, J. J., Mevorach, R., Vorobiev, L., Magen, I., Kunkes, E., Borges, B., Lichtman, A. H., & Berry, E. M. (2011). Fish oil promotes survival and protects against cognitive decline in severely undernourished mice by normalizing satiety signals. *Journal of Nutritional Biochemistry*, 22(8), 766–776.
- Babirekere-Iriso, E., Lauritzen, L., Mortensen, C. G., Rytter, M. J. H., Mupere, E., Namusoke, H., Michaelsen, K. F., Briend, A., Stark, K. D., Metherel, A. H., & Friis, H. (2016). Essential fatty acid composition and correlates in children with severe acute malnutrition. *Clinical Nutrition ESPEN*, 11, e40–e46.

- Baptista, P., & Andrade, J. P. (2018). Adult hippocampal neurogenesis: Regulation and possible functional and clinical correlates. *Frontiers in Neuroanatomy*, 12(June), 1–23. <https://doi.org/10.3389/fnana.2018.00044>
- Barness LA dan Curran JS, 2000. Nutrisi dalam Ilmu Kesehatan Anak Nelson, vol. 3, Edisi 15, Editor Behrman RE, Kliegman RM dan Arvin AM. Alih Bahasa A. Samik Wahab. EGC Jakarta, hlm. 211-4.
- Bechtholt-Gompf, A. J., Walther, H. V., Adams, M. A., Carlezon, W. A., Ngür, D., & Cohen, B. M. (2010). Blockade of astrocytic glutamate uptake in rats induces signs of anhedonia and impaired spatial memory. *Neuropsychopharmacology*, 35(10), 2049–2059.
- Bekinschtein P, Cammarota M, Igaz LM, Bevilacqua LRM, Izquierdo I dan Medina JH, 2007. Persistence of Long-Term Memory Storage Requires a Late Protein Synthesis- and BDNF-Dependent Phase in the Hippocampus. *Neuron*, vol. 53, pp. 261–277.
- Begum, G., Kintner, D., Liu, Y., Cramer, S. W., & Sun, D. (2012). DHA inhibits ER Ca²⁺ release and ER stress in astrocytes following in vitro ischemia. *Journal of Neurochemistry*, 120(4), 622–630.
- Boneva, N. B., Kikuchi, M., Minabe, Y., & Yamashima, T. (2011). Neuroprotective and ameliorative actions of polyunsaturated fatty acids against neuronal diseases: Implication of Fatty Acid - Binding Proteins (FABP) and G Protein - Coupled Receptor 40 (GPR40) in adult neurogenesis. *Journal of Pharmacological Sciences*, 116(2), 163–172.
- Boroujerdi, A., Kim, H. K., Lyu, Y. S., Kim, D. S., Figueroa, K. W., Chung, J. M., & Luo, Z. D. (2008). Injury discharges regulate calcium channel alpha-2-delta-1 subunit upregulation in the dorsal horn that contributes to initiation of neuropathic pain. *Pain*, 139(2), 358–366.
- Borovok, N., Nesher, E., Levin, Y., Reichenstein, M., Pinhasov, A., & Michaelievski, I. (2016). Dynamics of hippocampal protein expression during long-Term spatial memory formation. *Molecular and Cellular Proteomics*, 15(2), 523–541.
- Braga, N. N., Fukuda, M. T. H., & Almeida, S. S. (2014). Early postnatal protein malnutrition impairs recognition memory in rats (*Rattus norvegicus*). *Psychology and Neuroscience*, 7(2), 103–111.
- Burdge, G. C., Delange, E., Dubois, L., Dunn, R. L., Hanson, M. A., Jackson, A. A., & Calder, P. C. (2003). Effect of reduced maternal protein intake in pregnancy in the rat on the fatty acid composition of brain, liver, plasma, heart and lung phospholipids of the offspring after weaning. *British Journal of Nutrition*, 90(2), 345–352.

- Burdge, G. C., Dunn, R. L., Wootton, S. A., & Jackson, A. A. (2002). Effect of reduced dietary protein intake on hepatic and plasma essential fatty acid concentrations in the adult female rat: effect of pregnancy and consequences for accumulation of arachidonic and docosahexaenoic acids in fetal liver and brain. *British Journal of Nutrition*, 88(4), 379–387.
- Burgos, H., Hernández, A., Constandil, L., Ríos, M., Flores, O., Puentes, G., Hernández, K., Morgan, C., Valladares, L., Castillo, A., Cofre, C., Milla, L. A., Sáez-Briones, P., & Barra, R. (2019). Early postnatal environmental enrichment restores neurochemical and functional plasticities of the cerebral cortex and improves learning performance in hidden-prenatally-malnourished young-adult rats. *Behavioural Brain Research*, 363(October 2018), 182–190.
- Byrne, J. H. (2003). *Learning and Memory* (B. John (ed.); Second). Macmillan Reference.
- Calderon, F., & Kim, H. Y. (2004). Docosahexaenoic acid promotes neurite growth in hippocampal neurons. *Journal of Neurochemistry*, 90(4), 979–988.
- Cameron, H. A., & McKay, R. D. G. (2001). *LargePoolNewGranuleCells.pdf*. 417(November 2000), 406–417.
- Champeil-Potokar, G., Chaumontet, C., Guesnet, P., Lavialle, M., & Denis, I. (2006). Docosahexaenoic acid (22:6n-3) enrichment of membrane phospholipids increases gap junction coupling capacity in cultured astrocytes. *European Journal of Neuroscience*, 24(11), 3084–3090.
- Chattopadhyay, N., Singh, D. P., Heese, O., Godbole, M. M., Sinohara, T., Black, P. M., & Brown, E. M. (2000). Expression of peroxisome proliferator-activated receptors (PPARs) in human astrocytic cells: PPAR γ agonists as inducers of apoptosis. *Journal of Neuroscience Research*, 61(1), 67–74.
- Chmurzyńska, A. (2006). The multigene family of fatty acid-binding proteins (FABPs): Function, structure and polymorphism. *Journal of Applied Genetics*, 47(1), 39–48.
- Chung, W., Allen, N. J., & Eroglu, C. (2015). Astrocyte & synapse. *Cold Spring Harbor Laboratory Press*, 7(a020370), 1–19.
- Chung, W. L., Chen, J. J., & Su, H. M. (2008). Fish oil supplementation of control and (n-3) fatty acid-deficient male rats enhances reference and working memory performance and increases brain regional docosahexaenoic acid levels. *Journal of Nutrition*, 138(6), 1165–1171.
- Cocco, S., Podda, M. V., & Grassi, C. (2018). Role of BDNF signaling in memory enhancement induced by transcranial direct current stimulation. *Frontiers in Neuroscience*, 12(JUN), 1–8.
- Cohly, H. H. P., & Panja, A. (2005). Immunological Findings in Autism. *International Review of Neurobiology*, 71(05), 317–341.

- Cresto, N., Pillet, L. E., Billuart, P., & Rouach, N. (2019). Do Astrocytes Play a Role in Intellectual Disabilities? *Trends in Neurosciences*, 42(8), 518–527.
- Cruz-Rizzolo, R. J., Limieri, L. L., de Paiva, I. R., Ribeiro, J. O. B., Pimenta, T. F., Pinato, L., Ervolino, E., Casatti, C. A., Guissoni Campos, L. M., & Liberti, E. A. (2017). Protein malnutrition during gestation and early life decreases neuronal size in the medial prefrontal cortex of post-pubertal rats. *IBRO Reports*, 3, 65–71.
- Cunha, M. C. R., Lima, F. da S., Vinolo, M. A. R., Hastreiter, A., Curi, R., Borelli, P., & Fock, R. A. (2013). Protein Malnutrition Induces Bone Marrow Mesenchymal Stem Cells Commitment to Adipogenic Differentiation Leading to Hematopoietic Failure. *PLoS ONE*, 8(3), 1–12.
- Dahlan, MS (2010). *Besar sampel dan cara pengambilan sampel dalam penelitian kedokteran dan kesehatan* (3rd ed.). Salemba Medika.
- D’Hooge, R., & De Deyn, P. P. (2001). Applications of the Morris water maze in the study of learning and memory. In *Brain Research Reviews* (Vol. 36, Issue 1).
- de Castell, S., Jenson, J., & Larios, H. (2015). Gaming Experience and Spatial Learning in a Virtual Morris Water Maze. *Journal of Virtual Worlds Research*, 8(1), 1–18.
- DeFelipe J, Alonso-Nanclares L dan Arellano JI, 2002. Microstructure of the neocortex: Comparative aspects. *Journal of Neurocytology*, vol. 31, pp. 299–316.
- De Roo, M., Klauser, P., Garcia, P. M., Poglia, L., & Muller, D. (2008). Chapter 11 Spine dynamics and synapse remodeling during LTP and memory processes. *Progress in Brain Research*, 169(February), 199–207.
- De Souza, A. S., Fernandes, F. S., & Tavares Do Carmo, M. das G. (2011). Effects of maternal malnutrition and postnatal nutritional rehabilitation on brain fatty acids, learning, and memory. *Nutrition Reviews*, 69(3), 132–144.
- Diering, G. H., & Huganir, R. L. (2018). The AMPA Receptor Code of Synaptic Plasticity. *Neuron*, 100(2), 314–329.
- Dossi, E., Vasile, F., & Rouach, N. (2018). Human astrocytes in the diseased brain. *Brain Research Bulletin*, 136, 139–156.
- Dudai Y. (2012). The restless engram. *Annu Rev Neurosci*, 35, 227–247.
- Eady, T. N., Belayev, L., Khoutorova, L., Atkins, K. D., Zhang, C., & Bazan, N. G. (2012). Docosahexaenoic Acid Signaling Modulates Cell Survival in Experimental Ischemic Stroke Penumbra and Initiates Long-Term Repair in Young and Aged Rats. *PLoS ONE*, 7(10).

- Ebrahimi, M., Yamamoto, Y., Sharifi, K., Kida, H., Kagawa, Y., Yasumoto, Y., Islam, A., Miyazaki, H., Shimamoto, C., Maekawa, M., Mitsushima, D., Yoshikawa, T., & Owada, Y. (2016). Astrocyte-expressed FABP7 regulates dendritic morphology and excitatory synaptic function of cortical neurons. *Glia*, 64(1), 48–62.
- El-khayat, S Shaaban, EK Emam, A. E.-P. J. (2007). Cognitive function in Protein Energi malnutrition; in relation to long Chain Polyunsaturated Fatty Acids. *Pak J Biol Sci*, 10(11), 1773–1781.
- Elsherbiny, M. E., Goruk, S., Monckton, E. A., Richard, C., Brun, M., Emara, M., Field, C. J., & Godbout, R. (2015). Long-term effect of docosahexaenoic acid feeding on lipid composition and brain fatty acid-binding protein expression in rats. *Nutrients*, 7(10), 8802–8817.
- Epstein, R. A., Patai, E. Z., Julian, J. B., & Spiers, H. J. (2017). The cognitive map in humans: Spatial navigation and beyond. *Nature Neuroscience*, 20(11), 1504–1513.
- Escartin, C., Guillemaud, O., & Carrillo-de Sauvage, M. A. (2019). Questions and (some) answers on reactive astrocytes. *Glia*, 67(12), 2221–2247.
- Falk, S., & Götz, M. (2017). Glial control of neurogenesis. *Current Opinion in Neurobiology*, 47(Figure 1), 188–195.
- Feoli, A. M., Leite, M. C., Tramontina, A. C., Tramontina, F., Posser, T., Rodrigues, L., Swarowsky, A., Quincozes-Santos, A., Leal, R. B., Gottfried, C., Perry, M. L., & Gonçalves, C. A. (2008). Developmental changes in content of glial marker proteins in rats exposed to protein malnutrition. *Brain Research*, 1187(1), 33–41.
- Fuenzalida, K., Quintanilla, R., Ramos, P., Piderit, D., Fuentealba, R. A., Martinez, G., Inestrosa, N. C., & Bronfman, M. (2007). Peroxisome proliferator-activated receptor γ up-regulates the Bcl-2 anti-apoptotic protein in neurons and induces mitochondrial stabilization and protection against oxidative stress and apoptosis. *Journal of Biological Chemistry*, 282(51), 37006–37015.
- Galler, J. R., Bryce, C. P., Zichlin, M. L., Fitzmaurice, G., Eaglesfield, G. D., & Waber, D. P. (2012). Infant malnutrition is associated with persisting attention deficits in middle adulthood. *Journal of Nutrition*, 142(4), 788–794.
- Geisert, E. E., & Frankfurter, A. (1989). The neuronal response to injury as visualized by immunostaining of class III β -tubulin in the rat. *Neuroscience Letters*, 102(2–3), 137–141.
- Georgieff, M. K. (2007). Nutrition and the developing brain: Nutrient priorities and measurement. *American Journal of Clinical Nutrition*, 85(2), 614–620.

- Ghazalea, H., Ramadan, N., Mantasha, S., Zibarab, K., El-Sitti, S., Darwisha, H., Chamaad, F., Boustanya, R. M., Mondellog, S., Abou-Kheird, W., Soueida, J., & Kobeissya, F. (2017). Docosahexaenoic acid (DHA) enhances the therapeutic potential of neonatal neural stem cell transplantation post—Traumatic brain injury. *Behavioural Brain Research*, 340, 1–13.
- Gluck, M. A., Mercado, E., & Myers, C. (2014). *Learning and Memory From Brain To Behavior* (second). Worth Publishers.
- Granados-Rojas, L., Aguilar, A., & Díaz-Cintra, S. (2004). The mossy fiber system of the hippocampal formation is decreased by chronic and postnatal but not by prenatal protein malnutrition in rats. *Nutritional Neuroscience*, 7(5–6), 301–308.
- Guyton AC dan Hall JE. (2016). Thoughts, consciousness, and memory: The nervous system. In *Textbook of medical physiology* (thirteenth, pp. 745–747). Elsevier.
- Hajjar, T., Meng, G. Y., Rajion, M. A., Vidyadaran, S., Othman, F., Farjam, A. S., Li, T. A., & Ebrahimi, M. (2012). Omega 3 polyunsaturated fatty acid improves spatial learning and hippocampal Peroxisome Proliferator Activated Receptors (PPAR α and PPAR γ) gene expression in rats. *BMC Neuroscience*, 13(1).
- Hara, T., Umaru, B. A., Sharifi, K., Yoshikawa, T., Owada, Y., & Kagawa, Y. (2020). Fatty acid binding protein 7 is involved in the proliferation of reactive astrocytes, but not in cell migration and polarity. *Acta Histochemica et Cytochemica*, 53(4), 73–81.
- He, C., Qu, X., Cui, L., Wang, J., & Kang, J. X. (2009). Improved spatial learning performance of fat-1 mice is associated with enhanced neurogenesis and neuritogenesis by docosahexaenoic acid. *Proceedings of the National Academy of Sciences of the United States of America*, 106(27), 11370–11375.
- He, Z., Sun, Z., Liu, S., Zhang, Q., & Tan, Z. (2009). Effects of early malnutrition on mental system, metabolic syndrome, immunity and the gastrointestinal tract. *Journal of Veterinary Medical Science*, 71(9), 1143–1150.
- Hisaoka-Nakashima, K., Kajitani, N., Kaneko, M., Shigetou, T., Kasai, M., Matsumoto, C., Yokoe, T., Azuma, H., Takebayashi, M., Morioka, N., & Nakata, Y. (2016). Amitriptyline induces brain-derived neurotrophic factor (BDNF) mRNA expression through ERK-dependent modulation of multiple BDNF mRNA variants in primary cultured rat cortical astrocytes and microglia. *Brain Research*, 1634, 57–67.
- Hol, E. M., & Pekny, M. (2015). Glial fibrillary acidic protein (GFAP) and the astrocyte intermediate filament system in diseases of the central nervous system. *Current Opinion in Cell Biology*, 32, 121–130.

- Holub BJ, 2002. Clinical nutrition: 4. Omega-3 fatty acids in cardiovascular care. *Canadian Medical Association Journal (CMAJ)*, vol. 166, no. 5, pp. 608-15.
- Horgusluoglu, E., Nudelman, K., Nho, K., & Saykin, A. J. (2017). Adult Neurogenesis and Neurodegenerative Diseases: A Systems Biology Perspective. *Am J Med Genet B Neuropsychiatr Genet*, 174(1), 93–112.
- Hsieh, J. C., Liu, L., Zeilani, M., Ickes, S., Trehan, I., Maleta, K., Craig, C., Thakwalakwa, C., Singh, L., Thomas Brenna, J., & Manary, M. J. (2015). High-Oleic Ready-to-Use Therapeutic Food Maintains Docosahexaenoic Acid Status in Severe Malnutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 61(1), 138–143.
- Irwanto, & Sudarmo, S. M. (2013). Protein kinase C and calcium/calmodulin-dependent protein kinase II signaling on hippocampal neurogenesis in Wistar rat after Docosahexanoic acid (DHA) supplementation. *South Asian Journal of Experimental Biology*, 3(5), 226–231.
- Joaquim, A. O., Coelho, C. P., Motta, P. D., Felício, L. F., Bondan, E. F., Teodorov, E., Martins, M. F. M., Kirsten, T. B., Bonamin, L. V., & Bernardi, M. M. (2017). Maternal food restriction in rats of the F0 generation increases retroperitoneal fat, the number and size of adipocytes and induces periventricular astrogliosis in female F1 and male F2 generations. *Reproduction, Fertility and Development*, 29(7), 1340–1348.
- Joardar, A., Sen, A. K., & Das, S. (2006). Docosahexaenoic acid facilitates cell maturation and β -adrenergic transmission in astrocytes. *Journal of Lipid Research*, 47(3), 571–581.
- Kagawa, Y., Yasumoto, Y., Sharifi, K., Ebrahimi, M., Islam, A., Miyazaki, H., Yamamoto, Y., Sawada, T., Kishi, H., Kobayashi, S., Maekawa, M., Yoshikawa, T., Takaki, E., Nakai, A., Kogo, H., Fujimoto, T., & Owada, Y. (2015). Fatty acid-binding protein 7 regulates function of caveolae in astrocytes through expression of caveolin-1. *Glia*, 63(5), 780–794.
- Kan, I., Melamed, E., Offen, D., & Green, P. (2007). Docosahexaenoic acid and arachidonic acid are fundamental supplements for the induction of neuronal differentiation. *Journal of Lipid Research*, 48(3), 513–517.
- Kandel, E. R. (2012). The molecular biology of memory: CAMP, PKA, CRE, CREB-1, CREB-2, and CPEB. *Molecular Brain*, 5(1), 1.
- Kar, B. R., Rao, S. L., & Chandramouli, B. A. (2008). Cognitive development in children with chronic protein energy malnutrition. *Behavioral and Brain Functions*, 4, 1–12.
- Kawakita, E., Hashimoto, M., & Shido, O. (2006). Docosahexaenoic acid promotes neurogenesis in vitro and in vivo. *Neuroscience*, 139(3), 991–997.
- Kemenkes. (2018). Hasil Utama Riset Kesehatan Dasar (RISKESDAS).

- Khan, G. N., Turab, A., Khan, M. I., Rizvi, A., Shaheen, F., Ullah, A., Hussain, A., Hussain, I., Ahmed, I., Yaqoob, M., Ariff, S., & Soofi, S. B. (2016). Prevalence and associated factors of malnutrition among children under-five years in Sindh, Pakistan: A cross-sectional study. *BMC Nutrition*, 2(1), 1–7.
- Killooy, K. M., Harlan, B. A., Pehar, M., & Vargas, M. R. (2020). FABP7 upregulation induces a neurotoxic phenotype in astrocytes. *Glia*, 68(12), 2693–2704.
- Kim, B., Lee, E., Seong, R. H., Chung, H., & Son, H. (2010). Normal Adult Hippocampal Neurogenesis in SRG3-overexpressing Transgenic Mice. *Experimental Neurobiology*, 19(1), 39–48.
- Kipp, M., Clarner, T., Gingele, S., Pott, F., Amor, S., Van Der Valk, P., & Beyer, C. (2011). Brain lipid binding protein (FABP7) as modulator of astrocyte function. *Physiological Research*, 60(SUPPL.1).
- Kitajka, K., Sinclair, A. J., Weisinger, R. S., Weisinger, H. S., Mathai, M., Jayasooriya, A. P., Halver, J. E., & Puskás, L. G. (2004). Effects of dietary omega-3 polyunsaturated fatty acids on brain gene expression. *Proceedings of the National Academy of Sciences of the United States of America*, 101(30), 10931–10936.
- Knierim, J. J. (2015). The hippocampus. *Current Biology*, 25(23), R1116–R1121.
- Koizumi, S., Hirayama, Y., & Morizawa, Y. M. (2018). New roles of reactive astrocytes in the brain; an organizer of cerebral ischemia. *Neurochemistry International*, 119, 107–114.
- Kowianski, P., Lietzau, G., Czuba, E., Was'kow, M., Steliga, A., & Morys, J. (2018). BDNF A Key Factor With Multipotent impact on brain signaling and Synaptic Plasticity. *Cell Mol Neurobiol*, 38, 579–593.
- Krisnansari, D. (2010). Nutrisi Dan Gizi Buruk. *Mandala of Health*, 4(1), 60–68.
- Krzisch, M., Fülling, C., Jabinet, L., Armida, J., Gebara, E., Cassé, F., Habbas, S., Volterra, A., Hornung, J. P., & Toni, N. (2017). Synaptic adhesion molecules regulate the integration of new granule neurons in the postnatal mouse hippocampus and their impact on spatial memory. *Cerebral Cortex*, 27(8), 4048–4059.
- Kuipers, S. D., Trentani, A., Tiron, A., Mao, X., Kuhl, D., & Bramham, C. R. (2016). BDNF-induced LTP is associated with rapid Arc/Arg3.1-dependent enhancement in adult hippocampal neurogenesis. *Scientific Reports*, 6(January), 1–14.
- Laus, M. F., Vales, L. D. M. F., Costa, T. M. B., & Almeida, S. S. (2011). Early postnatal protein-calorie malnutrition and cognition: A review of human and animal studies. *International Journal of Environmental Research and Public Health*, 8(2), 590–612.

- Leuner, B., & Gould, E. (2010). Structural plasticity and hippocampal function. *Annual Review of Psychology*, 61(Shors 2008), 111–140.
- Liddelow, S. A., & Barres, B. A. (2017). Reactive Astrocytes: Production, Function, and Therapeutic Potential. *Immunity*, 46(6), 957–967.
- Liddelow, S. A., Guttenplan, K. A., Clarke, L. E., Bennett, F. C., Bohlen, C. J., Schirmer, L., Bennett, M. L., Münch, A. E., Chung, W. S., Peterson, T. C., Wilton, D. K., Frouin, A., Napier, B. A., Panicker, N., Kumar, M., Buckwalter, M. S., Rowitch, D. H., Dawson, V. L., Dawson, T. M., ... Barres, B. A. (2017). Neurotoxic reactive astrocytes are induced by activated microglia. *Nature*, 541(7638), 481–487.
- Liu, J., Liu, Y., Wang, X. F., Chen, H., & Yang, N. (2013). Antenatal taurine supplementation improves cerebral neurogenesis in fetal rats with intrauterine growth restriction through the PKA-CREB signal pathway. *Nutritional Neuroscience*, 16(6), 282–287.
- Liu Y, Yan Y, Inagaki Y, Logan S, Bonsjak ZJ, B. X. (2017). Insufficient Astrocyte-Derived BDNF Contributes to PropofolInduced Neuron Death through Akt/GSK3 β /Mitochondrial Fission Pathway. *Anesth Analg*, 125(1), 241–254.
- Lopes, T. de S., Quintana, H. T., Bortolin, J. A., Matos Alves, P. H., Bolina Matos, R. de S., Liberti, E. A., & Oliveira, F. de. (2017). Protein Malnutrition Pre- and Postnatal and Nutritional Rehabilitation Modulates the Morphology of Muscle Fibers in Wistar Rats. *Journal of Dietary Supplements*, 14(3), 278–287.
- Lynch, A. . (2004). Long-term potentiation and memory. *Physiol Rev*, 84, 87–136.
- Ma, K., Xiong, N., Shen, Y., Han, C., Liu, L., Zhang, G., Wang, L., Guo, S., Guo, X., Xia, Y., Wan, F., Huang, J., Lin, Z., & Wang, T. (2018). Weight loss and malnutrition in patients with Parkinson's Disease: Current knowledge and future prospects. *Frontiers in Aging Neuroscience*, 10(JAN), 1–19.
- Maragakis, N. J., & Rothstein, J. D. (2006). Mechanisms of Disease: Astrocytes in neurodegenerative disease. *Nature Clinical Practice Neurology*, 2(12), 679–689.
- Mariani, M., Karki, R., Spennato, M., Pandya, D., He, S., Andreoli, M., Fiedler, P., & Ferlini, C. (2015). Class III β -tubulin in Normal and Cancer tissues. *Gene*, 563(2), 109–114.
- Marszalek, J. R., & Lodish, H. F. (2005). Docosahexaenoic acid, fatty acid-interacting proteins, and neuronal function: Breastmilk and fish are good for you. *Annual Review of Cell and Developmental Biology*, 21, 633–657.

- Marwarha, G., Claycombe-Larson, K., Schommer, J., & Ghribi, O. (2017). Maternal low-protein diet decreases brain-derived neurotrophic factor expression in the brains of the neonatal rat offspring. *Journal of Nutritional Biochemistry*, 45, 54–66.
- Matos, R. J. B., Orozco-Solís, R., Lopes de Souza, S., Manhães-de-Castro, R., & Bolaños-Jiménez, F. (2011). Nutrient restriction during early life reduces cell proliferation in the hippocampus at adulthood but does not impair the neuronal differentiation process of the new generated cells. *Neuroscience*, 196, 16–24.
- Maximin, E., Langelier, B., Aïoun, J., Al-Gubory, K. H., Bordat, C., Lavialle, M., & Heberden, C. (2016). Fatty acid binding protein 7 and n-3 poly unsaturated fatty acid supply in early rat brain development. *Developmental Neurobiology*, 76(3), 287–297.
- Minatohara, K., Akiyoshi, M., & Okuno, H. (2016). Role of immediate-early genes in synaptic plasticity and neuronal ensembles underlying the memory trace. *Frontiers in Molecular Neuroscience*, 8(JAN2016), 1–11.
- Mita, T., Mayanagi, T., Ichijo, H., Fukumoto, K., Otsuka, K., Sakai, A., & Sobue, K. (2016). Docosahexaenoic acid promotes axon outgrowth by translational regulation of tau and collapsin response mediator protein 2 expression. *Journal of Biological Chemistry*, 291(10), 4955–4965.
- Molofsk, A. V., Krenick, R., Ullian, E., Tsai, H. H., Deneen, B., Richardson, W. D., Barres, B. A., & Rowitch, D. H. (2012). Astrocytes and disease: A neurodevelopmental perspective. *Genes and Development*, 26(9), 891–907.
- Morgan, P.J., Mokler, D.J., & Galler, J.R. (2002). Effects of prenatal protein malnutrition on the hippocampal formation. *Neuroscience and Biobehavioral Reviews*, 26, 471–483.
- Moriguchi, T., & Salem, N. (2003). Recovery of brain docosahexaenoate leads to recovery of spatial task performance. *Journal of Neurochemistry*, 87(2), 297–309.
- Morris, J. H. (2005). sistem saraf. In Robin & Cotran (Ed.), *Dasar Patologi Penyakit* (7th ed., pp. 1374–1375). Penerbit Buku Kedokteran EGC.
- Morrison, R. F., & Farmer, S. R. (2000). Hormonal signaling and transcriptional control of adipocyte differentiation. *Journal of Nutrition*, 130(12), 3116–3121.
- Mosher, K. I., & Schaffer, D. V. (2018). Influence of Hippocampal Niche Signals on Neural Stem Cell Functions During Aging. *Cell Tissue Res*, 371(1), 115–124.

- Musaelyan, K., Egeland, M., Fernandes, C., Pariante, C. M., Zunszain, P. A., & Thuret, S. (2014). Modulation of adult hippocampal neurogenesis by early-life environmental challenges triggering immune activation. *Neural Plasticity*, 2014.
- Naik, A. A., Patro, N., Seth, P., & Patro, I. K. (2017). Intra-generational protein malnutrition impairs temporal astrogenesis in rat brain. *Biology Open*, 6(7), 931–942.
- Niemoller, T., & Bazan, N. (2010). Docosaehaenoic Acid Neurolipidomics. *Prostaglandins Other Lipid Mediat*, 91(3–4), 85–89.
- Nikawa, T., Odahara, K., Koizumi, H., Kido, Y., Teshima, S., Rokutan, K., & Kishi, K. (1999). *Biochemical and Molecular Action of Nutrients Vitamin A Prevents the Decline in Immunoglobulin A and Th2 Cytokine Levels in Small Intestinal Mucosa of Protein-Malnourished Mice 1*. November 1998, 934–941.
- Nikoletopoulou, V., Sidiropoulou, K., Kallergi, E., Dalezios, Y., & Tavernarakis, N. (2017). Modulation of Autophagy by BDNF Underlies Synaptic Plasticity. *Cell Metabolism*, 26(1), 230-242.e5.
- Oberheim NA, Wang X, Goldman S dan Nedergaard M, 2006. Astrocytic complexity distinguishes the human brain. *Trends in Neurosciences*, vol. 29, no.10, pp. 547-53.
- Ota, Y., Zanetti, A. T., & Hallock, R. M. (2013). The role of astrocytes in the regulation of synaptic plasticity and memory formation. *Neural Plasticity*, 2013.
- Panizzutti, B., Bortolasci, C., Hasebe, K., Kidnapillai, S., Gray, L., Walder, K., Berk, M., Mohebbi, M., Dodd, S., Gama, C., Magalhães, P. V., Cotton, S. M., Kapczinski, F., Bush, A. I., Malhi, G. S., & Dean, O. M. (2018). Mediator effects of parameters of inflammation and neurogenesis from a N-acetyl cysteine clinical-trial for bipolar depression. *Acta Neuropsychiatrica*, 30(6), 334–341.
- Pastalkova, E., Serrano, P., Pinkhasova, D., Wallace, E., Fenton, A. A., & Sacktor, T. C. (2006). Storage of spatial information by the maintenance mechanism of LTP. In *Science* (Vol. 313, Issue 5790, pp. 1141–1444).
- Pekny, M., Pekna, M., Messing, A., Steinhäuser, C., Lee, J. M., Parpura, V., Hol, E. M., Sofroniew, M. V., & Verkhratsky, A. (2016). Astrocytes: a central element in neurological diseases. *Acta Neuropathologica*, 131(3), 323–345.
- Pérez-García, G., Guzmán-Quevedo, O., Da Silva Aragaõ, R., & Bolanõs-Jiménez, F. (2016). Early malnutrition results in long-lasting impairments in pattern-separation for overlapping novel object and novel location memories and reduced hippocampal neurogenesis. *Scientific Reports*, 6(February), 1–12.

- Petsophonsakul, P., Richetin, K., Andraini, T., Roybon, L., & Rampon, C. (2017). Memory formation orchestrates the wiring of adult-born hippocampal neurons into brain circuits. *Brain Structure and Function*, 222(6), 2585–2601.
- Portillo-Reyes, V., Pérez-García, M., Loya-Méndez, Y., & Puente, A. E. (2014). Clinical significance of neuropsychological improvement after supplementation with omega-3 in 8-12 years old malnourished Mexican children: A randomized, double-blind, placebo and treatment clinical trial. *Research in Developmental Disabilities*, 35(4), 861–870.
- Prado, E. L., & Dewey, K. G. (2014). Nutrition and brain development in early life. *Nutrition Reviews*, 72(4), 267–284.
- Purves D, Augustine DJ, Hall WC, Lamantia AS, McNamara JO dan Williams SM, 2004. Human memory in Neuroscience, Third edition. Sinauer Associated Inc, Massachusetts, pp, 108-13.
- Quesseveur, G., David, D. J., Gaillard, M. C., Pla, P., Wu, M. V., Nguyen, H. T., Nicolas, V., Auregan, G., David, I., Dranovsky, A., Hantraye, P., Hen, R., Gardier, A. M., Déglon, N., & Guiard, B. P. (2013). BDNF overexpression in mouse hippocampal astrocytes promotes local neurogenesis and elicits anxiolytic-like activities. *Translational Psychiatry*, 3(March).
- Ranade, P. S., & Rao, S. S. (2013). Maternal long-chain PUFA supplementation during protein deficiency improves brain fatty acid accretion in rat pups by altering the milk fatty acid composition of the dam. *Journal of Nutritional Science*, 2, 1–8.
- Rao, J. S., Ertley, R. N., Lee, H. J., DeMar, J. C., Arnold, J. T., Rapoport, S. I., & Bazinet, R. P. (2007). n-3 Polyunsaturated fatty acid deprivation in rats decreases frontal cortex BDNF via a p38 MAPK-dependent mechanism. *Molecular Psychiatry*, 12(1), 36–46.
- Reyes-Castro, Padilla-Gómez, Parga-Martínez, Castro-Rodríguez, Díaz-Cintra, Q., , Nathanielsz, Z., & . (2018). Hippocampal mechanisms in impaired spatial learning and memory in male offspring of rats fed a low-protein isocaloric diet in pregnancy and/or lactation. *Hippocampus*, 28(1), 18–30.
- Robel, S., Berninger, B., & Götz, M. (2011). The stem cell potential of glia: Lessons from reactive gliosis. *Nature Reviews Neuroscience*, 12(2), 88–104.
- Roshankhah, S., Sadeghi, E., Jalili, C., & Salahshoor, M. R. (2019). Impacts of Low-Protein Diet on the Hippocampal CA1 Neurons and Learning Deficits in Rats. *Advances in Human Biology*, 9, 124–128.
- Rossi, D. J., Brady, J. D., & Mohr, C. (2007). Astrocyte metabolism and signaling during brain ischemia. *Nature Neuroscience*, 10(11), 1377–1386.

- Santos de Souza, A., da Camara Pacheco, L., da Silva Castro, P., Hokoç, J. N., Santos Rocha, M., & Tavares do Carmo, M. das G. (2008). Brain fatty acid profiles and spatial learning in malnourished rats: Effects of nutritional intervention. *Nutritional Neuroscience*, 11(3), 119–127.
- Schmid, R. S., Yokota, Y., & Anton, E. S. (2006). Generation and characterization of brain lipid-binding protein promoter-based transgenic mouse models for the study of radial glia. *Glia*, 53(4), 345–351.
- Schmidt, N. O., Koeder, D., Messing, M., Mueller, F. J., Aboody, K. S., Kim, S. U., Black, P. M., Carroll, R. S., Westphal, M., & Lamszus, K. (2009). Vascular endothelial growth factor-stimulated cerebral microvascular endothelial cells mediate the recruitment of neural stem cells to the neurovascular niche. *Brain Research*, 1268, 24–37.
- Setiadji, VS (2012). *Neurotransmitter: reseptor dan cara kerja*. Badan Penerbit Fakultas Kedokteran UI.
- Sharifi, K., Morihiro, Y., Maekawa, M., Yasumoto, Y., Hoshi, H., Adachi, Y., Sawada, T., Tokuda, N., Kondo, H., Yoshikawa, T., Suzuki, M., & Owada, Y. (2011). FABP7 expression in normal and stab-injured brain cortex and its role in astrocyte proliferation. *Histochemistry and Cell Biology*, 136(5), 501–513.
- Silver, J. (2016). The glial scar is more than just astrocytes. *Experimental Neurology*, 286, 147–149.
- Singh, R. P., Shiue, K., Schomberg, D., & Zhou, F. C. (2009). Cellular epigenetic modifications of neural stem cell differentiation. *Cell Transplantation*, 18(10–11), 1197–1211.
- Sinha, S., Patro, N., Tiwari, P. K., & Patro, I. K. (2020). Maternal Spirulina supplementation during pregnancy and lactation partially prevents oxidative stress, glial activation and neuronal damage in protein malnourished F1 progeny. *Neurochemistry International*, 104877.
- Smit, E. N., Muskiet, F. A. J., & Boersma, E. R. (2004). The possible role of essential fatty acids in the pathophysiology of malnutrition: A review. *Prostaglandins Leukotrienes and Essential Fatty Acids*, 71(4), 241–250.
- Smit, E. N., Oelen, E. A., Seerat, E., Muskiet, F. A. J., & Boersma, E. R. (2000). Breast milk docosahexaenoic acid (DHA) correlates with DHA status of malnourished infants. *Archives of Disease in Childhood*, 82(6), 493–494.
- Smith, G. S., Sciences, B., Barrett, F. S., Sciences, B., Joo, J. H., Sciences, B., Nassery, N., Savonenko, A., & Sodums, D. J. (2018). *HHS Public Access*. 33–41.
- Smith, J., & Mangkoewidjojo, S. (1988). *Pemeliharaan, pembiakan dan penggunaan hewan percobaan di daerah tropis*. UI Press.

- Soares, R. O., Oliveira, L. M., Marchini, J. S., Rodrigues, J. A., Elias, L. L. K., & Almeida, S. S. (2013). Effects of early protein malnutrition and environmental stimulation on behavioral and biochemical parameters in rats submitted to the elevated plus-maze test. *Nutritional Neuroscience*, 16(3),
- Sofroniew, M. V., & Vinters, H. V. (2010). Astrocytes: Biology and pathology. *Acta Neuropathologica*, 119(1), 7–35.
- Sona, C., Dograa, S., Ajeet Kumara, Arun, B., Umrao, D., & Yadav, P. N. (2018). Docosahexaenoic acid modulates brain-derived neurotrophic factor via GPR40 in the brain and alleviates diabetes-associated learning and memory deficits in mice. *Neurobiology of Disease*, 118, 94–107.
- Song, H., Stevens, C. F., & Gage, F. H. (2002). Astroglia induce neurogenesis from adult neural stem cells. *Nature*, 417(6884), 39–44.
- Squire LR, 1986. Mechanisms of memory. Science, vol. 2, pp. 1612-9.
- Stangl, D., & Thuret, S. (2009). Impact of diet on adult hippocampal neurogenesis. *Genes and Nutrition*, 4(4), 271–282.
- Stella, F., Cerasti, E., Si, B., Jezek, K., & Treves, A. (2012). Self-organization of multiple spatial and context memories in the hippocampus. *Neuroscience and Biobehavioral Reviews*, 36(7), 1609–1625.
- Stipursky, J., Francis, D., & Gomes, F. C. A. (2012). Activation of MAPK/PI3K/SMAD pathways by TGF- β 1 controls differentiation of radial glia into astrocytes in vitro. *Developmental Neuroscience*, 34(1), 68–81.
- Stoica L, Zhu PJ, Huang W, Zhou H, Kozma SC dan Costa-Mattioli M, 2011. Selective pharmacogenetic inhibition of mammalian target of rapamycin complex I (mTORC1) blocks long-term synaptic plasticity and memory storage. *Proceeding of National Academy of Sciences (PNAS)*, vol. 108, no. 9, pp. 3791–6.
- Strokin, M., Sergeeva, M., & Reiser, G. (2003). Docosahexaenoic acid and arachidonic acid release in rat brain astrocytes is mediated by two separate isoforms of phospholipase A 2 and is differently regulated by cyclic AMP and Ca²⁺. *British Journal of Pharmacology*, 139(5), 1014–1022.
- Suliman, N. A., Taib, C. N. M., Moklas, M. A. M., & Basir, R. (2018). Delta-9-Tetrahydrocannabinol (Δ 9-THC) Induce Neurogenesis and Improve Cognitive Performances of Male Sprague Dawley Rats. *Neurotoxicity Research*, 33(2), 402–411.
- Syahrul, M., Zainuddin, A., & Thuret, S. (2012). *Nutrition , adult hippocampal neurogenesis and mental health*. 89–114.
- Tran, P. B., Banisadr, G., Ren, D., Chenn, A., & Miller, R. J. (2007). Chemokine Receptor Expression by Neural Progenitor Cells in Neurogenic Regions of Mouse Brain. *J Comp Neurol*, 500(6), 1007–1033.

- Tripathi, S., Kushwaha, R., Mishra, J., Gupta, M. K., Kumar, H., Sanyal, S., Singh, D., Sanyal, S., Sahasrabuddhe, A. A., Kamthan, M., Mudiam, M. K. R., & Bandyopadhyay, S. (2017). Docosahexaenoic acid up-regulates both PI3K/AKT-dependent FABP7–PPAR γ interaction and MKP3 that enhance GFAP in developing rat brain astrocytes. *Journal of Neurochemistry*, 140(1), 96–113.
- Uauy, R., & Dangour, A. D. (2006). Nutrition in brain development and aging: Role of essential fatty acids. *Nutrition Reviews*, 64(5 SUPPL. 1).
- Valadares, C. T., Fukuda, M. T. H., Françolin-Silva, A. L., Hernandez, A. S., & Almeida, S. S. (2010). Effects of postnatal protein malnutrition on learning and memory procedures. *Nutritional Neuroscience*, 13(6), 274–282.
- Van, A. Lo, Hachem, M., Lagarde, M., & Bernoud-Hubac, N. (2019). Omega-3 docosahexaenoic acid is a mediator of fate-decision of adult neural stem cells. *International Journal of Molecular Sciences*, 20(17), 1–18.
- Verkhatsky, A., Rodríguez, J. J., & Parpura, V. (2013). Astroglia in neurological diseases. *Future Neurology*, 8(2), 149–158.
- Vicidomini, C., Guo, N., & Sahay, A. (2020). Communication, Cross Talk, and Signal Integration in the Adult Hippocampal Neurogenic Niche. *Neuron*, 105(2), 220–235.
- Wang, H., Jiang, R., He, Q., Zhang, Y., Zhang, Y., Li, Y., Zhuang, R., Luo, Y., Li, Y., Wan, J., Tang, Y., Yu, H., Jiang, Q., & Yang, J. (2012). Expression pattern of peroxisome proliferator-activated receptors in rat hippocampus following cerebral ischemia and reperfusion injury. *PPAR Research*, 2012.
- Wang, L., & Xu, R. J. (2007). The effects of perinatal protein malnutrition on spatial learning and memory behaviour and brain-derived neurotrophic factor concentration in the brain tissue in young rats. *Asia Pacific Journal of Clinical Nutrition*, 16(SUPPL.1), 467–472.
- Wang, T., Yuan, W., Liu, Y., Zhang, Y., Wang, Z., Zhou, X., Ning, G., Zhang, L., Yao, L., Feng, S., & Kong, X. (2015). The role of the JAK-STAT pathway in neural stem cells, neural progenitor cells and reactive astrocytes after spinal cord injury. *Biomedical Reports*, 3(2), 141–146.
- Woo, N. H., & Lu, B. (2009). BDNF in Synaptic Plasticity and Memory. *Encyclopedia of Neuroscience*, 135–143.
- Yan, X., Zhao, X., Li, J., He, L., & Xu, M. (2018). Effects of early-life malnutrition on neurodevelopment and neuropsychiatric disorders and the potential mechanisms. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 83, 64–75.
- Yudiarto, F., Putra, S. T., & Kasan, U. (2011). Memori ditinjau dari neuroanatomi dan biomolekuler. In *Psikoneuroimunologi Kedokteran* (Edisi 2, pp. 205–218). Airlangga University Press.

- Zdaniuk, G., Wierzbą-Bobrowicz, T., Szpak, G. M., & Stępień, T. (2011). Astroglia disturbances during development of the central nervous system in fetuses with Down's syndrome. *Folia Neuropathologica*, 49(2), 109–114.
- Zhao, C., Deng, W., & Gage, F. H. (2008). Mechanisms and Functional Implications of Adult Neurogenesis. *Cell*, 132(4), 645–660.
- Zou, Y., Watters, A., Cheng, N., Perry, C. E., Xu, K., Alicea, G. M., Parris, J. L. D., Baraban, E., Ray, P., Nayak, A., Xu, X., Herlyn, M., Murphy, M. E., Weeraratna, A. T., Schug, Z. T., & Chen, Q. (2019). Polyunsaturated fatty acids from astrocytes activate PPAR γ signaling in cancer cells to promote brain metastasis. *Cancer Discovery*, 9(12), 1720–1735.