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Neurodegeneration and inflammation crosstalk: Therapeutic targets and perspectives
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Abstract
Glia, which was formerly considered to exist just to connect neurons, now plays a key function in a wide range of physiological events, including formation of memory, learning, neuroplasticity, synaptic plasticity, energy consumption, and homeostasis of ions. Glial cells regulate the brain's immune responses and confers nutritional and structural aid to neurons, making them an important player in a broad range of neurological disorders. Alzheimer's, ALS, Parkinson's, frontotemporal dementia (FTD), and epilepsy are a few of the neurodegenerative diseases that have been linked to microglia and astroglia cells, in particular. Synapse growth is aided by glial cell activity, and this activity has an effect on neuronal signalling. Each glial malfunction in diverse neurodegenerative diseases is distinct, and we will discuss its significance in the progression of the illness, as well as its potential for future treatment. © 2023 The Authors

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Chemicals/CAS
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References

- Abbott, N.J.
  Astrocyte-endothelial interactions and bloodbrain barrier permeability
  (2002) *J. Anat.*, 200, pp. 629-638.
- Absinta, M., Maric, D., Gharagozloo, M., Garton, T., Smith, M.D., Jin, J., Fitzgerald, K.C., Reich, D.S.
  A lymphocyte-microglia-astrocyte axis in chronic active multiple sclerosis
  (2021) *Nature*, 597 (7878), pp. 709-714.
- (2020), Alzheimer's Association. Alzheimer's disease facts and figures. Alzheimers Dement. 16:391–460. doi: 10.1002/alz.12068.
- Andreone, B.J., Larhammar, M., Lewcock, J.W.
  Cell death and neurodegeneration

(2020) *Cold Spring Harb. Perspect. Biol.*, 12 (2).

- Araque, A., Parpura, V., Sanzgiri, R.P., Haydon, P.G.
Tripartite synapses: glia, the unacknowledged partner
(1999) *Trends Neurosci.*, 22, pp. 208-215.

- Armstrong, M.J., Litvan, I., Lang, A.E.
Criteria for the diagnosis of corticobasal degeneration
(2013) *Neurology*, 80, pp. 496-503.

- Baloh, R.H., Glass, J.D., Svendsen, C.N.
Stem cell transplantation for amyotrophic lateral sclerosis
(2018) *Curr. Opin. Neurol.*, 31 (5), pp. 655-661.

- Banerjee, S., Walseth, T.F., Borgmann, K., Wu, L., Bidasee, K.R., Kannan, M.S., Ghorpade, A.
CD38/Cyclic ADP-ribose regulates astrocyte calciumsignaling: implications for neuroinflammation andHIV-1-associated dementia
(2008) *J. Neuroimmun. Pharmacol.*, 3, pp. 154-164.

- Bayraktar, O.A., Bartels, T., Holmqvist, S., Kleshchevnikov, V., Martirosyan, A., Polioudakis, D.
Astrocyte layers in the mammalian cerebral cortex revealed by a single-cell in situ transcriptomic map
(2020) *Nat. Neurosci.*, 23, pp. 500-509.

- Bellaver, B., Ferrari-Souza, J.P., Uglione da Ros, L.
Astrocyte biomarkers in Alzheimer disease: a systematic review and meta-analysis
(2021) *Neurology*, 96 (24), pp. e2944-e2955.

- Bellaver, B., dos Santos, J.P., Leffa, D.T., Bobermin, L.D., Roppa, P.H.A., da Silva Torres, I.L., Gonçalves, C.A., Quincozes-Santos, A.
Systemic Inflammation as a Driver of Brain Injury: The Astrocyte as an Emerging Player
(2018) *Mol. Neurobiol.*, 55, pp. 2685-2695.

- Benedet, A.L., Wagner, S.B., Hansson, O., Karikari, T.K., Zimmer, E.R., Zetterberg, H., Blennow, K., Ashton, N.J.
The accuracy and robustness of plasma biomarker models for amyloid PET positivity
(2022) *Alzheimer'S. Res. Ther.*, no. 1, pp. 1-11.

- Benner, E.J., Mosley, R.L., Destache, C.J., Jackson-Lewis, V., Nemachek, C., Green, S., Przedborski, S., Gendelman, H.
Therapeutic immunization protects dopaminergic neurons in a mouse model of Parkinson's disease
(2004) *Proc. Natl. Acad. Sci. USA*, 101, p. 9435Y40.

- Betarbet, R., Sherer, T.B., Greenamyre, J.T.
Ubiquitin-proteasome system and Parkinson's diseases
(2005) *Exp. Neurol.*, 191, pp. S17-S27.

- Bezzi, P., Gundersen, V., Galbete, J.S., Seifert, G., Steinhauser, C., Pilati, E., Volterra, A.
Astrocytes contain a vesicular compartment that is competent for regulated exocytosis of glutamate
(2004) *Nat. Neurosci.*, 7, pp. 613-620.

- Blacher, E., Ben Baruch, B., Levy, A., Geva, N., Green, K.D., Garneau-Tsodikova, S., Fridman, M., Stein, R.
Inhibition of glioma progression by a newly discovered CD38 inhibitor
(2015) *Int. J. Cancer*, 136, pp. 1422-1433.

- Bliederhaeuser, C., Grozdanov, V., Speidel, A.
Age-dependent defects of alpha-synuclein oligomer uptake in microglia and monocytes
(2016) *Acta Neuropathol.*, 131 (3), p. 379e391.

- Braczynski, A.K., Schulz, J.B., Bach, J.-P.
Vaccination strategies in tauopathies and synucleinopathies
(2017) *J. Neurochem.*, 143, pp. 467-488.

- Brady, K.R.O., Kanfer, J., Shapiro, D.
The Metabolism of Glucocerebrosides. I. Purification and properties of a glucocerebroside-cleaving enzyme from spleen tissue
(1965) *J. Biol. Chem.*, 240, pp. 39-43.

- Braidy, N., Poljak, A., Grant, R., Jayasena, T., Mansour, H., Chan-Ling, T., Guillemin, G.J., Sachdev, P.
Mapping NAD+ metabolism in the brain of ageing Wistar rats: potential targets for influencing brain senescence
(2014) *Biogerontology*, 15, pp. 177-198.

- Braidy, N., Lim, C.K., Grant, R., Brew, B.J., Guillemin, G.J.
Serum nicotinamide adenine dinucleotide levels through disease course in multiple sclerosis
(2013) *Brain Res.*, 1537, pp. 267-272.

- Breslin, J.W., Yang, Y., Scallan, J.P., Sweat, R.S., Adderley, S.P., Murfee, W.L.
Lymphatic vessel network structure and physiology
(2018) *Compr. Physiol.*, 9 (1), pp. 207-299.

- Burfeind, K.G., Murchison, C.F., Westaway, S.K., Simon, M.J., Erten-Lyons, D., Kaye, J.A.
The effects of noncoding aquaporin-4 single-nucleotide polymorphisms on cognition and functional progression of Alzheimer's disease
(2017) *Alzheimers Dement (N.Y.)*, 3 (3), pp. 348-359.

- Buskila, Y., Bellot-Saez, A., Morley, J.W.
Generating brain waves, the power of astrocytes
(2019) *Front. Neurosci.*, 13, p. 1125.

- Cahoy, J.D., Emery, B., Kaushal, A., Foo, L.C., Zamanian, J.L., Christopherson, K.S.
A transcriptome database for astrocytes, neurons, and oligodendrocytes: a new resource for understanding brain development and function
(2008) *J. Neurosci.*, 28, pp. 264-278.
doi:10.1523/ JNEUROSCI.4178-07.2008

- Camacho-Pereira, J., Tarragó, M.G., Chini, C.C.S., Nin, V., Escande, C., Warner, G.M., Puranik, A.S., Galina, A.
CD38 Dictates age-related NAD decline and mitochondrial dysfunction through an SIRT3-dependent mechanism
(2016) *Cell Metab.*, 23, pp. 1127-1139.

- Camp, J.G., Badsha, F., Florio, M., Kanton, S., Gerber, T., Wilsch-Bräuninger, M.
Human cerebral organoids recapitulate gene expression programs of fetal neocortex development
(2015) *Proc. Natl. Acad. Sci.*, 112.
201520760

- Carballo-Carbajal, I., Laguna, A., Romero-Gim enez, J.
Brain tyrosinase overexpression implicates age-dependent neuromelanin production in Parkinson's disease pathogenesis
(2019) *Nat. Commun.*, 10 (1), p. 973e973.

- Carlstrom, L.P., Eltanahy, A., Perry, A., Rabinstein, A.A., Elder, B.D., Morris, J.M.
A clinical primer for the glymphatic system
(2021) *Brain*,

- Cartier, N., Lewis, C.A., Zhang, R., Rossi, F.M.V.
The role of microglia in human disease: therapeutic tool or target?
(2014) *Acta Neuropathol.*, 128, pp. 363-380.

- Castillo-Carranza, D.L., Guerrero-Muñoz, M.J., Sengupta, U.
Tau immunotherapy modulates both pathological tau and upstream amyloid pathology in an Alzheimer's disease mouse model
(2015) *J. Neurosci.*, 35, pp. 4857-4868.

- Catenaccio, A., Llavero Hurtado, M., Diaz, P., Lamont, D.J., Wishart, T.M., Court, F.A.
Molecular analysis of axonal-intrinsic and glial-associated co-regulation of axon degeneration
(2017) *Cell Death Dis.*, 8.

- Ceni, C., Pochon, N., Brun, V., Muller-Ste ner, H., Andrieux, A., Grunwald, D., Schuber, F., Villaz, M.
CD38-dependent ADP-ribosyl cyclase activity in developing and adult mouse brain
(2003) *Biochem. J.*, 370, pp. 175-183.

- Chai, H., Diaz-Castro, B., Shigetomi, E., Monte, E., Octeau, J.C., Yu, X.
Neural circuit-specialized astrocytes: transcriptomic, proteomic, morphological, and functional evidence
(2017) *Neuron*, 95 (3), pp. 531-549.

- Chandra, A., Farrell, C., Wilson, H., Dervenoulas, G., De Natale, E.R., Politis, M.
Aquaporin-4 polymorphisms predict amyloid burden and clinical outcome in the Alzheimer's disease spectrum
(2021) *Neurobiol. Aging*, 97, pp. 1-9.

- Chatterjee, D., Kordower, J.H.
Immunotherapy in Parkinson's disease: current status and future directions
(2019) *Neurobiol. Dis.*, 132.

- Chatterjee, Pratishtha, Pedrini, S., Stoops, E., Goozee, K., Villemagne, V.L., Asih, P.R., Verberk, M.W.
Plasma glial fibrillary acidic protein is elevated in cognitively normal older adults at risk of Alzheimer's disease
(2021) *Transl. Psychiatry*, 11 (1), pp. 1-10.

- Chen, R.L., Kassem, N.A., Redzic, Z.B., Chen, C.P., Segal, M.B., Preston, J.E.
Agerelated changes in choroid plexus and blood-cerebrospinal fluid barrier function in the sheep
(2009) *Exp. Gerontol.*, 44 (4), pp. 289-296.

- Chaves, M.L.
SerumlevelsofS100BandNSEproteins in Alzheimer's disease patients
(2010) *J. Neuroinflamm.*, 7, p. 6.

- Chen, W.T., Lu, A., Craessaerts, K., Pavie, B., Sala Frigerio, C., Corthout, N.
Spatial transcriptomics and in situ sequencing to study Alzheimer's disease
(2020) *Cell*, 182 (976), pp. e19-e91.
e19

- Choi, I., Zhang, Y., Seegobin, S.P.
Microglia clear neuron-released a-synuclein via selective autophagy and prevent

neurodegeneration
(2020) *Nat. Commun.*, 11 (1), p. 1386.

- Codolo, G., Plotegher, N., Pozzobon, T.
Triggering of inflammasome by aggregated a-synuclein, an inflammatory response in synucleinopathies
(2013) *PLoSOne*, 8 (1).
p. e55375-e55375

- Colangelo, A.M., Alberghina, L., Papa, M.
Astrogliosis as a therapeutic target for neurodegenerative diseases
(2014) *Neurosci. Lett.*, 565, pp. 59-64.

- Craig-Schapiro, R., Perrin, R.J., Roe, C.M., Xiong, C., Carter, D., Cairns, N.J.
YKL-40: a novel prognostic fluid biomarker for preclinical Alzheimer's disease
(2010) *Biol. Psychiatry*, 68, pp. 903-912.

- Cuevas-Diaz Duran, R., Wei, H., Kim, D.H., Wu, J.Q.
Invited Review: long non-coding RNAs: important regulators in the development, function and disorders of the central nervous system
(2019) *Neuropathol. Appl. Neurobiol.*, 45, pp. 538-556.

- Cui, H., Wang, W., Zheng, X., Xia, D., Liu, H., Qin, C.
Decreased AQP4 expression aggravates α-synuclein pathology in Parkinson's disease mice, possibly via impaired glymphatic clearance
(2021) *J. Mol. Neurosci.*, 71 (12), pp. 2500-2513.

- Cunningham, C., Dunne, A., Lopez-Rodriguez, A.B.
Astrocytes: heterogeneous and dynamic phenotypes in neurodegeneration and innate immunity
(2019) *Neuroscientist*, no. 5, pp. 455-474.

- Delage, C.I., Šimonˇciˇcová, E., Tremblay, M.È.
Microglial heterogeneity in aging and Alzheimer's disease: is sex relevant?
(2021) *J. Pharmacol. Sci.*, 146, pp. 169-181.

- Deleidi, M., Gasser, T.
The role of inflammation in sporadic and familial Parkinson's disease
(2013) *Cell. Mol. Life Sci.*, 70, pp. 4259-4273.

- Denk, J., Boelmans, K., Siegismund, C., Lassner, D., Arlt, S., Jahn, H.
MicroRNA profiling of CSF reveals potential biomarkers to detect Alzheimer‘s disease
(2015) *PLoS ONE*, 10.

- De Strooper, B., Karran, E.
The cellular phase of Alzheimer's disease
(2016) *Cell*, 164, pp. 603-615.

- Dickson, D.W.
Parkinson's disease and parkinsonism: neuropathology
(2012) *Cold Spring Harb. Perspect. Med*, p. 2.

- Diem, A.K., Carare, R.O., Weller, R.O., Bressloff, N.W.
A control mechanism for intra-mural peri-arterial drainage via astrocytes: how neuronal activity could improve waste clearance from the brain
(2018) *PLoS One*, 13 (10).

- Dileepan, M., Jude, J.A., Rao, S.P., Walseth, T.F., Panettieri, R.A., Subramanian, S., Kannan, M.S.
MicroRNA-708 regulates CD38 expression through signaling pathways JNK MAP

kinase and PTEN/AKT in human airway smooth muscle cells
(2014) *Respir. Res.*, 15, p. 107.

- Duran, R.C., Yan, H., Zheng, Y., Huang, X., Grill, R., Kim, D.H.
The systematic analysis of coding and long non-coding RNAs in the sub-chronic and chronic stages of spinal cord injury
(2017) *Sci. Rep.*, 7, p. 41008.

- Edler, M.K., Mhatre-Winters, I., Richardson, J.R.
Microglia in aging and Alzheimer's disease: a comparative species review
(2021) *Cells*, 10, p. 1138.

- Elyaman, W., Bradshaw, E.M., Uyttenhove, C., Dardalhon, V., Awasthi, A., Imitola, J., Bettelli, E., Renauld, J.-C.
IL-9 induces di erentiation of TH17 cells and enhances function of FoxP3+ natural regulatory T cells
(2009) *Proc. Natl. Acad. Sci. USA*, 106, pp. 12885-12890.

- Elyaman, W., Khoury, S.J.
Th9 cells in the pathogenesis of EAE and multiple sclerosis
(2017) *Semin. Immunopathol.*, 39, pp. 79-87.

- Escartin, C., Galea, E., Lakatos, A., O'Callaghan, J.P., Petzold, G.C., Serrano-Pozo, A.
Reactive astrocyte nomenclature, definitions, and future directions
(2021) *Nat. Neurosci.*, 24, pp. 312-325.

- Fardell, C., Zettergren, A., Ran, C., Belin, A.C., Ekman, A., Sydow, O., Bäckman, L., Söderkvist, P.
S100B polymorphisms are associated with age of onset of Parkinson's disease
(2018) *BMC Med. Genet.*,

- Fedorow, H., Tribl, F., Halliday, G., Gerlach, M., Riederer, P., Double, K.L.
Neuromelanin in human dopamine neurons: comparison with peripheral melanins and relevance to Parkinson's disease
(2005) *Prog. Neurobiol.*, 75 (2), p. 109e124.

- Fellin, T.
Communication between neurons and astrocytes: relevance to the modulation of synaptic and network activity
(2009) *J. Neurochem*, 108, pp. 533-544.

- Fiacco, T.A., Agulhon, C., McCarthy, K.D.
Sorting out astrocyte physiology from pharmacology
(2009) *Annu. Rev. Pharmacol. Toxicol.*, 49, pp. 151-174.

- Fleischman, D., Berdahl, J.P., Zaydlarova, J., Stinnett, S., Fautsch, M.P., Allingham, R.R.
Cerebrospinal fluid pressure decreases with older age
(2012) *PLoS ONE*, 7 (12).

- Fotuhi, S.N., Khalaj-Kondori, M., Hoseinpour Feizi, M.A., Talebi, M.
Long non-coding RNA BACE1-AS may serve as an Alzheimer's disease blood-based biomarker
(2019) *J. Mol. Neurosci.*, 69, pp. 351-359.

- Fukuyama, R.
The cerebrospinal fluid level of glial fibrillary acidic protein is increased in cerebrospinal fluid from Alzheimer's disease patients and correlates with severity of dementia
(2001) *Eur. Neurol.*, 46, pp. 35-38.

- Garcia-Marin, V., Garcia-Lopez, P., Freire, M.
Cajal's contributions to the study of Alzheimer's disease
(2007) *J. Alzheimers Dis.*, 12, pp. 161-174.

- GBD
Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016
(2016) *Lancet Neurol.*, 18 (1), pp. 88-106.
2019

- Gerhard, A., Banati, R.B., Goerres, G.B.
[11C](R)-PK11195 PET imaging of microglial activation in multiple system atrophy
(2003) *Neurology*, 61 (5), p. 686e689.

- Gerhard, A., Pavese, N., Hotton, G.
In vivo imaging of microglial activation with [11C](R)-PK11195 PET in idiopathic Parkinson's disease
(2006) *Neurobiol. Dis.*, 21 (2), p. 404e412.

- Guerreiro, S., Anne-Laure, P., Laurence, B., Damien, T.
CD38 in neurodegeneration and neuroinflammation
(2020) *Cells*, 9 (2), p. 471.

- Giandomenico, S.L., Mierau, S.B., Gibbons, G.M., Wenger, L.M., Masullo, L., Sit, T.
Cerebral organoids at the air–liquid interface generate diverse nerve tracts with functional output
(2019) *Nat. Neurosci.*, 22, pp. 669-679.

- Gleiser, C., Wagner, A., Fallier-Becker, P., Wolburg, H., Hirt, B., Mack, A.F.
Aquaporin- 4 in astroglial cells in the CNS and supporting cells of sensory organs-a comparative perspective
(2016) *Int. J. Mol. Sci.*, 17 (9), p. 1411.

- Goedert, M., Masuda-Suzukake, M., Falcon, B.
Like prions: the propagation of aggregated tau and alpha-synuclein in neurodegeneration
(2017) *Brain*, 140 (2), p. 266e278.

- Gong, C.X., Iqbal, K.
Hyperphosphorylation of microtubule-associated protein tau: a promising therapeutic target for Alzheimer disease
(2008) *Curr. Med Chem.*, 15, pp. 2321-2328.

- Gordon, R., Albornoz, E.A., Christie, D.C.
Inflammasome inhibition prevents a-synuclein pathology and dopaminergic neurodegeneration in mice
(2018) *Sci. Transl. Med.*, 10 (465), p. eaah4066.

- Grimes, D.A., Han, F., Panisset, M., Racacho, L., Xiao, F., Zou, R., Westa, K., Bulman, D.E.
Translated mutation in the Nurr1 gene as a cause for Parkinson's disease
(2006) *Mov. Disord.*, 21, pp. 906-909.

- Grozio, A., Sociali, G., Sturla, L., Ca a, I., Soncini, D., Salis, A., Ra aelli, N., Bruzzone, S.
CD73 Protein as a Source of Extracellular Precursors for Sustained NAD + Biosynthesis in FK866-treated
(2013) *Tumor Cells J. Biol. Chem.*, 288, pp. 25938-25949.

- Graeber, M.B., Li, W., Rodriguez, M.L.
Role of Microglia in CNS Inflammation
(2011) *FEBS Lett.*, 585, pp. 3798-3805.

- Grubman, A., Chew, G., Ouyang, J.F., Sun, G., Choo, X.Y., McLean, C.
A single-cell atlas of entorhinal cortex from individuals with Alzheimer's disease reveals cell-type-specific gene expression regulation
(2019) *Nat. Neurosci.*, 22, pp. 2087-2097.

- Gur-Wahnon, D., Mizrachi, T., Maaravi-Pinto, F.-Y., Lourbopoulos, A., Grigoriadis, N., Higazi, A.R., Brenner, T.
The plasminogen activator system: Involvement in central nervous system inflammation and a potential site for therapeutic intervention
(2013) *J. Neuroinflamm.*, 10, p. 124.

- Hablitz, L.M., Nedergaard, M.
The glymphatic system: a novel component of fundamental neurobiology
(2021) *J. Neurosci.*, 41 (37), pp. 7698-7711.

- Hablitz, L.M., Nedergaard, M.
The glymphatic system
(2021) *Curr. Biol.*, 31 (20), pp. R1371-R1375.

- Han, X., Sun, S., Sun, Y.
Small molecule-driven NLRP3 inflammation inhibition via interplay between ubiquitination and autophagy: implications for Parkinson disease
(2019) *Autophagy*, 15 (11).
1860e1881

- Harms, A.S., Delic, V., Thome, A.D.
alpha-Synuclein fibrils recruit peripheral immune cells in the rat brain prior to neurodegeneration
(2017) *Acta Neuropathol. Commun.*, 5 (1), p. 85e85.

- Harrison, I.F., Ismail, O., Machhada, A., Colgan, N., Ohene, Y., Nahavandi, P.
Impaired glymphatic function and clearance of tau in an Alzheimer's disease model
(2020) *Brain*, 143 (8), pp. 2576-2593.

- Harry, G.J.
Microglia in neurodegenerative events-an initiator or a significant other?
(2021) *Int. J. Mol. Sci.*, 22, p. 5818.

- Hart, A.D., Wyttenbach, A., Hugh Perry, V., Teeling, J.L.
Age related changes in microglial phenotype vary between CNS regions: grey versus white matter differences
(2012) *Brain Behav. Immun.*, 26, pp. 754-765.

- Hastings, N., Kuan, W.-L., Osborne, A., Kotter, M.R.N.
Therapeutic potential of astrocyte transplantation
(2022) *Cell Transplant.*, 31.

- Hayakawa, K., Esposito, E., Wang, X., Terasaki, Y., Liu, Y., Xing, C., Ji, X., Lo, E.H.
Transfer of mitochondria from astrocytes to neurons after stroke
(2016) *Nature*, 535, pp. 551-555.

- Helmut, K., Hanisch, U.K., Noda, M., Verkhratsky, A.
Physiology of Microglia
(2011) *Physiol. Rev.*, 91, pp. 461-553.

- Herrmann, M.M., Barth, S., Greve, B., Schumann, K.M., Bartels, A., Weissert, R.
Identification of gene expression patterns crucially involved in experimental autoimmune encephalomyelitis and multiple sclerosis
(2016) *Dis. Model. Mech.*, 9, pp. 1211-1220.

- Herms, J., Dorostkar, M.M.
Dendritic spine pathology in neurodegenerative diseases
(2016) *Annu Rev. Pathol.*, 11, pp. 221-250.

- Hirsch, E., Graybiel, A.M., Agid, Y.A.
Melanized dopaminergic neurons are differentially susceptible to degeneration in Parkinson's disease
(1988) *Nature*, 334 (6180), p. 345e348.

- Hou, Y., Dan, X., Babbar, M., Wei, Y., Hasselbalch, S.G., Croteau, D.L.
Ageing as a risk factor for neurodegenerative disease
(2019) *Nat. Rev. Neurol.*, 15 (10), pp. 565-581.

- Hov, K., Roksund, N., Bolstad, A.-V., Idland, H., Zetterberg, K., Blennow, Chaudhry, F.A., Watne, L.O.
Cerebrospinal fluid S100B and Alzheimer's disease biomarkers in hip fracture patients with delirium
(2017) *Dement. Geriatr. Cogn. Disord. Extra*, 7 (3), pp. 374-385.

- Hruska, K.K.S., Marca, K.M.E.L., Scott, C.R., Sidransky, E.
Gaucher disease: Mutation and polymorphism spectrum in the glucocerebrosidase gene (GBA)
(2008) *Hum. Mutat.*, 29, pp. 567-583.

- Huang, A.Y., Woo, J., Sardar, D., Lozzi, B., Bosquez Huerta, N.A., Lin, C.J.
Region-specific transcriptional control of astrocyte function oversees local circuit activities
(2020) *Neuron*, 106 (992), pp. e9-1008.

- Imamura, K., Hishikawa, N., Ono, K., Suzuki, H., Sawada, M., Nagatsu, T., Yoshida, M., Hashizume, Y.
Cytokine production of activated microglia and decrease in neurotrophic factors of neurons in the hippocampus of Lewy body disease brains
(2005) *Acta Neuropathol.*, 109, pp. 141-150.

- Iannaccone, S., Cerami, C., Alessio, M.
In vivo microglia activation in very early dementia with Lewy bodies, comparison with Parkinson's disease
(2013) *Park. Relat. Disord.*, 19 (1), p. 47e52.

- I liff, J.J., Wang, M., Liao, Y., Plogg, B.A., Peng, W., Gundersen, G.A.
A paravascular pathway facilitates CSF flow through the brain parenchyma and the clearance of interstitial solutes, including amyloid beta
(2012) *Sci. Transl. Med*, 4 (147), p. 147ra11.

- Iliff, J.J., Nedergaard, M.
Is there a cerebral lymphatic system?
(2013) *Stroke*, 44 (6), pp. S93-S95.

- Iliff, J.J., Wang, M., Zeppenfeld, D.M., Venkataraman, A., Plog, B.A., Liao, Y.
Cerebral arterial pulsation drives paravascular CSF-interstitial fluid exchange in the murine brain
(2013) *J. Neurosci.*, 33 (46), pp. 18190-18199.

- Iliff, J.J., Chen, M.J., Plog, B.A., Zeppenfeld, D.M., Soltero, M., Yang, L.
Impairment of glymphatic pathway function promotes tau pathology after traumatic brain injury
(2014) *J. Neurosci.*, 34 (49), pp. 16180-16193.

- Imamura, K., Hishikawa, N., Sawada, M., Nagatsu, T., Yoshida, M., Hashizume, Y.
Distribution of major histocompatibility complex class II-positive microglia and

cytokine profile of Parkinson's disease brains
(2003) *Acta Neuropathol.*, 106 (6), p. 518e526.

- Jackson, J., Jambrina, E., Li, J., Marston, H., Menzies, F., Phillips, K.
Targeting the synapse in Alzheimer's disease
(2019) *Front Neurosci.*, 13, p. 735.

- Jessen, N.A., Munk, A.S., Lundgaard, I., Nedergaard, M.
The glymphatic system: a Beginner's guide
(2015) *Neurochem Res*, 40 (12), pp. 2583-2599.

- Jellinger, K.A.
Neuropathological aspects of Alzheimer disease, Parkinson disease and frontotemporal dementia
(2008) *Neurodegener. Dis.*, 5, pp. 118-121.

- Jing, H., Wang, S., Wang, M., Fu, W., Zhang, C., Xu, D.
Isobavachalcone attenuates MPTP-induced Parkinson's disease in mice by inhibition of microglial activation through NF- B pathway
(2017) *PLoS ONE*, p. 12.

- John Lin, C.C., Yu, K., Hatcher, A., Huang, T.W., Lee, H.K., Carlson, J.
Identification of diverse astrocyte populations and their malignant analogs
(2017) *Nat. Neurosci.*, 20, pp. 396-405.

- Kalinowska, A., Losy, J.
PECAM-1, a key player in neuroinflammation
(2006) *Eur. J. Neurol.*, 13, pp. 1284-1290.

- Karpenko, M.N., Vasilishina, A.A., Gromova, E.A., Muruzheva, Z.M., Bernadotte, A.
Interleukin-1,interleukin-1 receptor antagonist, interleukin-6, interleukin-10, and tumor necrosis factor- levels in CSF and serum in relation to the clinical diversity of Parkinson's disease
(2018) *Cell. Immunol.*, 327, pp. 77-82.

- Kastner, A., Hirsch, E.C., Lejeune, O., Javoy-Agid, F., Rascol, O., Agid, Y.
Is the vulnerability of neurons in the substantia nigra of patients with Parkinson's disease related to their neuromelanin content?
(1992) *J. Neurochem*, 59 (3), p. 1080e1089.

- Kettenmann, H., Hanisch, U.K., Noda, M., Verkhratsky, A.
Physiology of microglia
(2011) *Physiol. Rev.*, 91, pp. 461-553.

- Khakh, B.S., Deneen, B.
The emerging nature of astrocyte diversity
(2019) *Annu Rev. Neurosci.*, 42, pp. 187-207.

- Kim, J.B., Yu, Y.M., Kim, S.W., Lee, J.K.
Anti-inflammatory Mechanism is Involved in Ethyl Pyruvate-Mediated Efficacious Neuroprotection in the Postischemic Brain
(2005) *Brain Res*, 1060, pp. 188-192.

- Kim, Y.S., Choi, D.H., Block, M.L.
A pivotal role of matrix metalloproteinase-3 activity in dopaminergic neuronal degeneration via microglial activation
(2007) *FASEB J.*, 21 (1), p. 179e187.

- Kim, C., Ho, D.H., Suk, J.E.
Neuron-released oligomeric a-synuclein is an endogenous agonist of TLR2 for

paracrine activation of microglia
(2013) *Nat. Commun.*, 4, p. 1562.

- Kim, S., Kim, T., Lee, H.-R., Jang, E.-H., Ryu, H.-H., Kang, M., Rah, S.-Y., Kim, J.-I.
Impaired learning and memory in CD38 null mutant mice
(2016) *Mol. Brain*, 9, p. 16.

- Kohl, Z., Schlachetzki, J.C., Feldewerth, J.
Distinct pattern of microgliosis in the olfactory bulb of neurodegenerative proteinopathies
(2017) *Neural Plast.*, 2017.
p. 3851262e3851262

- Kou, W., Banerjee, S., Eudy, J., Smith, L.M., Persidsky, R., Borgmann, K., Wu, L., Walseth, T.F.
CD38 regulation in activated astrocytes: Implications for neuroinflammation and HIV-1 brain infection
(2009) *J. Neurosci. Res.*, 87, pp. 2326-2339.

- Kress, B.T., Iliff, J.J., Xia, M., Wang, M., Wei, H.S., Zeppenfeld, D.
Impairment of paravascular clearance pathways in the aging brain
(2014) *Ann. Neurol.*, 76 (6), pp. 845-861.

- Kunz, A., Abe, T., Hochrainer, K.
Nuclear factor-kappaB activation and postischemic inflammation are suppressed in CD36-null mice after middle cerebral artery occlusion
(2008) *J. Neurosci.*, 28 (7), p. 1649e1658.

- Lamkanfi, M., Dixit, V.M.
Inflammasomes and their roles in health and disease
(2012) *Annu Rev. Cell Dev. Biol.*, 28, p. 137e161.

- Lautrup, S., Sinclair, D.A., Mattson, M.P., Fang, E.F.
NAD+ in brain aging and neurodegenerative disorders
(2019) *Cell Metab.*, 30, pp. 630-655.

- Lepore, A.C., O'Donnell, J., Kim, A.S., Williams, T., Tuteja, A., Rao, M.S., Kelley, L.L., Maragakis, N.J.
Human Glial-restricted progenitor transplantation into cervical spinal cord of the SOD1 G93A mouse model of ALS
(2011) *PLoS ONE*, 6 (10), pp. 1-17.

- Liddelow, S.A., Guttenplan, K.A., Clarke, L.E., Bennett, F.C., Bohlen, C.J., Schirmer, L.
Neurotoxic reactive astrocytes are induced by activated microglia
(2017) *Nature*, 541, pp. 481-487.

- Liu, J.X., Cao, X., Liu, Y., Tang, F.R.
CCL28 in the mouse hippocampal CA1 area and the dentate gyrus during and after pilocarpine-induced status epilepticus
(2012) *Neurochem. Int.*, 61, pp. 1094-1101.

- Llorens, F., Thüne, K., Tahir, W., Kanata, E., Diaz-Lucena, D., Xanthopoulos, K., Kovatsi, E.
YKL-40 in the brain and cerebrospinal fluid of neurodegenerative dementias
(2017) *Mol. Neurodegener.*, 12 (1), pp. 1-21.

- Ma, Y., Jiang, J., Wang, L., Nie, H., Xia, W., Liu, J., Ying, W.
CD38 is a key enzyme for the survival of mouse microglial BV2 cells
(2012) *Biochem. Biophys. Res. Commun.*, 418, pp. 714-719.

- Malavasi, F., Deaglio, S., Funaro, A., Ferrero, E., Horenstein, A.L., Ortolan, E., Vaisitti, T., Aydin, S.
  Evolution and function of the ADP Ribosyl Cyclase/CD38 gene family in physiology and pathology
  (2008) *Physiol. Rev.*, 88, pp. 841-886.

- Mamik, M.K., Banerjee, S., Walseth, T.F., Hirte, R., Tang, L., Borgmann, K., Ghorpade, A.
  HIV-1 and IL-1 regulate astrocytic CD38 through mitogen-activated protein kinases and nuclear factor- B signaling mechanisms
  (2011) *J. Neuroinflamm.*, 8, p. 145.

- Mandler, M., Valera, E., Rockenstein, E., Weninger, H., Patrick, C., Adame, A., Santic, R., Smrzka, O.
  Next-generation active immunization approach for synucleinopathies: implications for Parkinson's disease clinical trials
  (2014) *Acta Neuropathol.*, 127, pp. 861-879.

- Mansour, A.A., Gonçalves, J.T., Bloyd, C.W., Li, H., Fernandes, S., Quang, D.
  An in vivo model of functional and vascularized human brain organoids
  (2018) *Nat. Biotechnol.*, 36, pp. 432-441.

- Marschallinger, J.; Iram, T.; Zardeneta, M.; Lee, S.E.; Lehallier, B.; Haney, M.S.; Pluvinage, J.V.; Mathur, V.; Hahn, O.;

- Mathiisen, T.M., Lehre, K.P., Danbolt, N.C., Ottersen, O.P.
  The perivascular astroglial sheath provides a complete covering of the brain microvessels: an electron microscopic 3D reconstruction
  (2010) *Glia*, 58, pp. 1094-1103.

- Mathias, I., Morgado, J., Gomes, F.C.A.
  Astrocyte heterogeneity: Input to brain aging and disease
  (2019) *Front. Aging Neurosci.*, 11, p. 59.

- Mathys, H., Davila-Velderrain, J., Peng, Z., Gao, F., Mohammadi, S., Young, J.Z.
  Single-cell transcriptomic analysis of Alzheimer's disease
  (2019) *Nature*, 570, pp. 332-337.

- Mayo, L., Jacob-Hirsch, J., Amariglio, N., Rechavi, G., Moutin, M.-J., Lund, F.E., Stein, R.
  Dual Role of CD38 in microglial activation and activation-induced cell death
  (2008) *J. Immunol.*, 181, pp. 92-103.

- Mazzulli, J.R., Xu, Y.-H., Sun, Y., Knight, A.L., McLean, P.J., Caldwell, G.A., Grabowski, G.A., Krainc, D.
  Gaucher disease glucocerebrosidase and alpha-synuclein form a bidirectional pathogenic loop in synucleinopathies
  (2011) *Cell*, 146, pp. 37-52.

- McCoy, M.K., Martinez, T.N., Ruhn, K.A., Szymkowski, D.E., Smith, C.G., Botterman, B.R., Tansey, K.E., Tansey, M.G.
  Blocking soluble tumor necrosis factor signaling with dominant-negative tumor necrosis factor inhibitor attenuates loss of dopaminergic neurons in models of Parkinson's disease
  (2006) *J. Neurosci. O. J. Soc. Neurosci.*, 26, pp. 9365-9375.

- McGeer, P.L., McGeer, E.G.
  Inflammation and the degenerative diseases of aging
  (2004) *Ann. N. Y. Acad. Sci.*, 1035, pp. 104-116.

- McKeith, I.G., Dickson, D.W., Lowe, J.
  Diagnosis and management of dementia with Lewy bodies
  (2005) *Neurology*, 65 (12), p. 1863.

- Mecocci, P.
Serum anti-GFAP and anti-S100 autoantibodies in brain aging, Alzheimer's disease and vascular dementia
(1995) *J. Neuroimmunol.*, 57, pp. 165-170.

- Meldolesi, J.
Astrocytes: news about brain health and diseases
(2020) *Biomedicines*, 8 (10), p. 394.

- Mestre, H., Hablitz, L.M., Xavier, A.L., Feng, W., Zou, W., Pu, T.
Aquaporin- 4-dependent glymphatic solute transport in the rodent brain
(2018) *Elife*, 7.

- Mestre, H., Tithof, J., Du, T., Song, W., Peng, W., Sweeney, A.M.
Flow of cerebrospinal fluid is driven by arterial pulsations and is reduced in hypertension
(2018) *Nat. Commun.*, 9 (1), p. 4878.

- Mestre, H., Mori, Y., Nedergaard, M.
The brain's glymphatic system: current controversies
(2020) *Trends Neurosci.*, 43 (7), pp. 458-466.

- Milo, R.
Therapies for multiple sclerosis targeting B cells
(2019) *Croat. Med. J.*, 60, pp. 87-98.

- Mizuguchi, M., Otsuka, N., Sato, M., Ishii, Y., Kon, S., Yamada, M., Nishina, H., Ikeda, K.
Neuronal localization of CD38 antigen in the human brain
(1995) *Brain Res.*, 697, pp. 235-240.

- Mohan, T., Deng, L., Wang, B.Z.
CCL28 chemokine: an anchoring point bridging innate and adaptive immunity
(2017) *Int. Immunopharmacol.*, 51, pp. 165-170.

- Mondello, S., Constantinescu, R., Zetterberg, H., Andreasson, U., Holmberg, B., Jeromin, A.
CSF -synuclein and UCH-L1 levels in Parkinson's disease and atypical parkinsonian disorders
(2014) *Park. Relat. Disord.*, 20, pp. 382-387.

- Morra, L.F., Donovick, P.J.
Clinical presentation and differential diagnosis of dementia with Lewy bodies: a review
(2014) *Int J. Geriatr. Psychiatr.*, 29 (6), p. 569e576.

- Nakatsuka, T., Imabayashi, E., Matsuda, H., Sakakibara, R., Inaoka, T., Terada, H.
Discrimination of dementia with Lewy bodies from Alzheimer's disease using voxel-based morphometry of white matter by statistical parametric mapping plus diffeomorphic anatomic registration through exponentiated Liealgebra
(2013) *Neuroradiology*, 55 (5), p. 559e566.

- Nedergaard, M., Goldman, S.A.
Glymphatic failure as a final common pathway to dementia
(2020) *Science*, 370 (6512), pp. 50-56.

- Nicaise, C., Mitrecic, D., Falnikar, A., Lepore, A.C.
Transplantation of stem cell-derived astrocytes for the treatment of amyotrophic lateral sclerosis and spinal cord injury
(2015) *World J. Stem Cells*, 7 (2), pp. 380-398.

- Olsson, B.
  CSF and blood biomarkers for the diagnosis of Alzheimer's disease: a systematic review and meta-analysis
  (2016) *Lancet Neurol.*, 15, pp. 673-684.

- O'Neil, S.M., Witcher, K.G., McKim, D.B., Godbout, J.P.
  Forced turnover of aged microglia induces an intermediate phenotype but does not rebalance CNS environmental cues driving priming to immune challenge
  (2018) *Acta Neuropathol. Commun.*, 6, p. 129.

- Orellana, J.A., Stehberg, J.
  Hemichannels: new roles in astroglial function
  (2014) *Front Physiol.*, 5, p. 193.

- Otsuka, K., Mizuguchi, M., Aizawa, T., Haga, S., Sato, M., Inoya, H., Namba, Y., Machinami, R.
  Immunoreactivity in Alzheimer's neurofibrillary tangles (abstract)
  (1994) *Brain Pathol.*, 4, p. 558.

- Ouchi, Y., Yoshikawa, E., Sekine, Y.
  Microglial activation and dopamine terminal loss in early Parkinson's disease
  (2005) *Ann. Neurol.*, 57 (2), p. 168e175.

- Palop, J.J., Mucke, L.
  Amyloid-beta-induced neuronal dysfunction in Alzheimer's disease: from synapses toward neural networks
  (2010) *Nat. Neurosci.*, 13 (7), pp. 812-818.

- Park, J.-S., Kam, T.-I., Lee, S., Park, H., Oh, Y., Kwon, S.-H., Song, J.-J., Lee, S.
  Blocking microglial activation of reactive astrocytes is neuroprotective in models of Alzheimer's disease
  (2021) *Acta Neuropathol. Commun.*, 9 (1), p. 15.

- Parnetti, L., Chiasserini, D., Persichetti, E., Eusebi, P., Varghese, S., Qureshi, M.M., Dardis, A., Castrioto, A.
  Cerebrospinal fluid lysosomal enzymes and alpha-synuclein in Parkinson's disease
  (2014) *Mov. Disord.*, 29, pp. 1019-1027.

- Pekny, M., Pekna, M.
  Astrocyte reactivity and reactive astrogliosis: costs and benefits
  (2014) *Physiol. Rev.*, 94, pp. 1077-1098.

- Pekny, M., Pekna, M., Messing, A., Steinhäuser, C., Lee, J.M., Parpura, V.
  Astrocytes: a central element in neurological diseases
  (2016) *Acta Neuropathol.*, 131, pp. 323-345.

- Peng, C., Gathagan, R.J., Lee, V.M.
  Distinct alpha-Synuclein strains and implications for heterogeneity among alpha-Synucleinopathies
  (2018) *Neurobiol. Dis.*, 109, p. 209e218.

- Pereira, J.B., Janelidze, S., Smith, R., Mattsson-Carlgren, N., Palmqvist, S., Teunissen, C.E., Zetterberg, H.
  Plasma GFAP is an early marker of amyloid-β but not tau pathology in Alzheimer's disease
  (2021) *Brain*, 144 (11), pp. 3505-3516.

- Perry, V.H., Matyszak, M.K., Fearn, S.
  Altered antigen expression of microglia in the aged rodent CNS
  (1993) *Glia*, 7, pp. 60-67.

- Peter, I., Dubinsky, M., Bressman, S., Park, A., Lu, C., Chen, N., Wang, A.
  Anti–tumor necrosis factor therapy and incidence of Parkinson disease among patients with inflammatory Bowel disease
  (2018) *JAMA Neurol.*, 75, pp. 939-946.

- Picca, A., Guerra, F., Calvani, R., Marini, F., Biancolillo, A., Landi, G., Beli, R., Bentivoglio, A.R.
  Mitochondrial signatures in circulating extracellular vesicles of older adults with Parkinson's disease: results from the exosomes in Parkinson's disease (EXPAND) study
  (2020) *J. Clin. Med.*, 9, p. 504.

- Plog, B.A., Nedergaard, M.
  The glymphatic system in central nervous system health and disease: past, present, and future
  (2018) *Annu Rev. Pathol.*, 13, pp. 379-394.

- Poly, T.N., Islam, M.M.R., Yang, H.-C., Li, Y.-C.J.
  Non-steroidal anti-inflammatory drugs and risk of Parkinson's disease in the elderly population: a meta-analysis
  (2019) *Eur. J. Clin. Pharmacol.*, 75, pp. 99-108.

- Querol-Vilaseca, M.
  YKL-40 (chitinase 3-like I) is expressed in a subset of astrocytes in Alzheimer's disease and other tauopathies
  (2017) *J. Neuroinflamm.*, 14, p. 118.

- Quintas, C., Vale, N., Gonçalves, J., Queiroz, G.
  Microglia P2Y(13) receptors prevent astrocyte proliferation mediated by P2Y(1) receptors
  (2018) *Front. Pharmacol.*, 9, p. 418.

- Quintana, D.S., Rokicki, J., van der Meer, D., Alnæs, D., Kaufmann, T., Córdova-Palomera, A., Dieset, I., Westlye, L.T.
  Oxytocin pathway gene networks in the human brain
  (2019) *Nat. Commun.*, 10, p. 668.

- Rainey-Smith, S.R., Mazzucchelli, G.N., Villemagne, V.L., Brown, B.M., Porter, T., Weinborn, M.
  Genetic variation in Aquaporin-4 moderates the relationship between sleep and brain Aβ-amyloid burden
  (2018) *Transl. Psychiatry*, 8 (1), p. 47.

- Rasmussen, M.K., Mestre, H., Nedergaard, M.
  Fluid transport in the brain
  (2021) *Physiol. Rev.*, 102, pp. 1025-1151.

- Rees, K., Stowe, R., Patel, S., Ives, N., Breen, K., Clarke, C.E., Ben-Shlomo, Y.
  Non-steroidal anti-inflammatory drugs as disease-modifying agents for Parkinson's disease: evidence from observational studies
  (2011) *Cochrane Database Syst. Rev.*, p. 11.
  CD008454

- Respondek, G., Stamelou, M., Kurz, C.
  Movement Disorder Society-endorsed PSP study group. The phenotypic spectrum of progressive supranuclear palsy: a retrospective multicenter study of 100 definite cases
  (2014) *Mov. Disord.*, 29, pp. 1758-1766.

- Roboon, J., Hattori, T., Ishii, H., Takarada-Iemata, M., Le, T.M., Shiraishi, Y., Ozaki, N., Okamoto, H.

Deletion of CD38 suppresses glial activation and neuroinflammation in a mouse model of demyelination
(2019) *Front. Cell. Neurosci.*, 13, p. 258.

- Rodríguez-Gómez, J.A., Kavanagh, E., Engskog-Vlachos, P., Engskog, M.K.R., Herrera, A.J., Espinosa-Oliva, A.M., Joseph, B., Burguillos, M.A.
Microglia: agents of the CNS pro-inflammatory response
(2020) *Cells*, 9, p. 1717.

- Saad, M., Lesage, S., Saint-Pierre, A., Corvol, J.-C., Zelenika, D., Lambert, J.-C., Vidailhet, M., Durif, F.
Genome-wide association study confirms BST1 and suggests a locus on 12q24 as the risk loci for Parkinson's disease in the European population
(2011) *Hum. Mol. Genet.*, 20, pp. 615-627.

- Saijo, K., Glass, C.K.
Microglial cell origin and phenotypes in health and disease
(2011) *Nat. Rev. Immunol.*, 11, pp. 775-787.

- Salminen, A., Ojala, J., Kaarniranta, K., Haapasalo, A., Hiltunen, M., Soininen, H.
Astrocytes in the aging brain express characteristics of senescence-associated secretory phenotype
(2011) *Eur. J. Neurosci.*, 34, pp. 3-11.

- Salter, M.W., Stevens, B.
Microglia emerge as central players in brain disease
(2017) *Nat. Med.*, 23, pp. 1018-1027.

- Sanchez-Guajardo, V., Annibali, A., Jensen, P.H., Romero-Ramos, M.
Synuclein vaccination prevents the accumulation of Parkinson disease like pathologic inclusions in striatum in association with regulatory T Cell recruitment in a rat model
(2013) *J. Neuropathol. Exp. Neurol.*, 72, pp. 624-645.

- Santaella, A., Kuiperij, H.B., van Rumund, A., Esselink, R.A., van Gool, A.J., Bloem, B.R., Verbeek, M.M.
Inflammation biomarker discovery in Parkinson's disease and atypical parkinsonisms
(2020) *BMC Neurol.*, p. 26.

- Shi, X., Wang, B., Liu, Y., Zhang, J., Huang, Y., Cao, P., Shen, Y., Lyu, J.
Carnosine modulates glutamine synthetase expression in senescent astrocytes exposed to oxygen-glucose deprivation/recovery
(2017) *Brain Res. Bull.*, 130, pp. 138-145.

- Sidransky, E.
Gaucher disease and parkinsonism
(2005) *Mol. Genet. Metab.*, 84, pp. 302-304.

- Simon, J.D., Peles, D., Wakamatsu, K., Ito, S.
Current challenges in understanding melanogenesis: bridging chemistry, biological control, morphology, and function
(2009) *Pigment Cell Melanoma Res.*, 22 (5), p. 563e579.

- Simpson, J.E., Ince, P.G., Lace, G., Forster, G., Shaw, P.J., Matthews, F., Savva, G., Wharton, S.B.
Astrocyte phenotype in relation to alzheimer-type pathology in the ageing brain
(2010) *Neurobiol. Aging*, 31, pp. 578-590.

- Singh, A., Abraham, W.C.
“Astrocytes and synaptic plasticity in health and disease.”

(2017) *Exp. Brain Res.*, 235 (6), pp. 1645-1655.

- Smith, A.J., Yao, X., Dix, J.A., Jin, B.J., Verkman, A.S.
  Test of the "glymphatic" hypothesis demonstrates diffusive and aquaporin-4-independent solute transport in rodent brain parenchyma
  (2017) *Elife*, 6.

- Sofroniew, M.V.
  Astrogliosis
  (2014) *Cold Spring Harb. Perspect. Biol.*, 7.

- Sofroniew, M.V.
  Multiple roles for astrocytes as effectors of cytokines and inflammatory mediators
  (2014) *Neuroscientist*, 20, pp. 160-172.

- Sonntag, K.-C., Ryu, W.-I., Amirault, K.M., Healy, R.A., Siegel, A.J., McPhie, D.L., Forester, B., Cohen, B.M.
  Late-onset Alzheimer's disease is associated with inherent changes in bioenergetics profiles
  (2017) *Sci. Rep.*, 7, p. 14038.

- Spillantini, M.G., Goedert, M.
  The alpha-synucleinopathies: Parkinson's disease, dementia with Lewy bodies, and multiple system atrophy
  (2000) *Ann. N. Y Acad. Sci.*, 920, p. 16e27.

- Streit, W.J., Mrak, R.E., Griffin, W.S.T.
  Microglia and neuroinflammation: a pathological perspective
  (2004) *J. Neuroinflamm.*, 1, p. 14.

- Sun, F., Lin, C.L., McTigue, D., Shan, X., Tovar, C.A., Bresnahan, J.C.
  Effects of axon degeneration on oligodendrocyte lineage cells: dorsal rhizotomy evokes a repair response while axon degeneration rostral to spinal contusion induces both repair and apoptosis
  (2010) *Glia*, 58, pp. 1304-1319.

- Su, X., Maguire-Zeiss, K.A., Giuliano, R., Prifti, L., Venkatesh, K., Federoff, H.J.
  Synuclein activates microglia in a model of Parkinson's disease
  (2008) *Neurobiol. Aging*, 29 (11), p. 1690e1701.

- Surendranathan, A., Su, L., Mak, E.
  Early microglial activation and peripheral inflammation in dementia with Lewy bodies
  (2018) *Brain J. Neurol.*, 141 (12), p. 3415e3427.

- Takizawa, C., Thompson, P.L., van Walsem, A., Faure, C., Maier, W.C.
  Epidemiological and economic burden of Alzheimer's disease: a systematic literature review of data across Europe and the United States of America
  (2015) *J. Alzheimers Dis.*, 43, pp. 1271-1284.

- Tang, P., Chong, L., Li, X., Liu, Y., Liu, P., Hou, C., Li, R.
  Correlation between serum RANTES levels and the severity of Parkinson's disease
  (2014) *Oxid. Med. Cell Longev.*, 2014.

- Tarragó, M.G., Chini, C.C.S., Kanamori, K.S., Warner, G.M., Caride, A., de Oliveira, G.C., Rud, M., Huang, R.
  A potent and specific CD38 inhibitor ameliorates age-related metabolic dysfunction by reversing tissue NAD+ decline
  (2018) *Cell Metab.*, 27, pp. 1081-1095.
  e10

- Tarasoff-Conway, J.M., Carare, R.O., Osorio, R.S., Glodzik, L., Butler, T., Fieremans, E.
Clearance systems in the brain-implications for Alzheimer disease
(2015) *Nat. Rev. Neurol.*, 11 (8), pp. 457-470.

- Tayebi, N., Walker, J., Stubblefield, B., Orvisky, E., Marca, M.E.L., Wong, K., Rosenbaum, H., Sidransky, E.
Gaucher disease with parkinsonian manifestations: does glucocerebrosidase deficiency contribute to a vulnerability to parkinsonism?
(2003) *Mol. Genet. Metab.*, 79, pp. 104-109.

- Taylor, J.P., Brown, R.H., Cleveland, D.W.
Decoding ALS: from genes to mechanism
(2016) *Nature*, 539, pp. 197-206.

- Tremblay, M.È., Zettel, M.L., Ison, J.R., Allen, P.D., Majewska, A.K.
Effects of aging and sensory loss on glial cells in mouse visual and auditory cortices
(2012) *Glia*, 60, pp. 541-558.

- Tremblay, M.E., Zhang, I., Bisht, K., Savage, J.C., Lecours, C., Parent, M., Titorenko, V., Maysinger, D.
Remodeling of lipid bodies by docosahexaenoic acid in activated microglial cells
(2016) *J. Neuroinflamm.*, 13, p. 116.

- Trias, E., Barbeito, L., Yamanaka, K.
Phenotypic heterogeneity of astrocytes in motor neuron disease
(2018) *Clin. Exp. Neuroimmunol.*, 9, pp. 225-234.

- Valori, C.F., Possenti, A., Brambilla, L., Rossi, D.
Challenges and opportunities of targeting astrocytes to halt neurodegenerative disorders
(2021) *Cells*, 10 (8).

- van de Donk, N.W.J., Usmani, S.Z.
CD38 antibodies in multiple myeloma: mechanisms of action and modes of resistance
(2018) *Front. Immunol.*, 9, p. 2134.

- Verberk, I.M., Thijssen, E., Koelewijn, J.
Combination of plasma amyloid beta (1-42/1-40) and glial fibrillary acidic protein strongly associates with cerebral amyloid pathology
(2020) *Alzheimers Res Ther.*, 12, pp. 1-4.

- Verkhratsky, A.
Physiology of neuronal-glial networking
(2010) *Neurochem. Int.*, 57, pp. 332-343.

- Verkhratsky, A., Rodríguez, J.J., Parpura, V.
Astroglia in neurological diseases
(2013) *Future Neurol.*, 8, pp. 149-158.

- Verkhratsky, A., Parpura, V.
Astrogliopathology in neurological, neurodevelopmental and psychiatric disorders
(2016) *Neurobiol. Dis.*, 85, pp. 254-261.

- Verkhratsky, A., Nedergaard, M.
The homeostatic astroglia emerges from evolutionary specialization of neural cells
(2016) *Philos. Trans. R. Soc. Lond. B Biol. Sci.*, 371.

- Verkhratsky, A., Nedergaard, M.
Physiology of astroglia

(2018) *Physiol. Rev.*, 98, pp. 239-389.

- Verkhratsky, A., Matteoli, M., Parpura, V., Mothet, J.P., Zorec, R.
Astrocytes as secretory cells of the central nervous system: idiosyncrasies of vesicular secretion
(2016) *EMBO J.*, 35, pp. 239-257.

- Villarreal, A., Vidos, C., Monteverde Busso, M., Cieri, M.B., Ramos, A.J.
Pathological neuroinflammatory conversion of reactive astrocytes is induced by microglia and involves chromatin remodeling
(2021) *Front. Pharmacol.*, 12 (June), pp. 1-15.

- Virchow, R.
Cellular Pathology as Based Upon Physiological and Pathological Histology
(1860), John Churchill London

- Von Bernhardi, R., Heredia, F., Salgado, N., Muñoz, P.
Microglia function in the normal brain
(2016) *Adv. Exp. Med. Biol.*, 949, pp. 67-92.

- Wagner, J., Ryazanov, S., Leonov, A.
Anle138b: a novel oligomer modulator for disease-modifying therapy of neurodegenerative diseases such as prion and Parkinson's disease
(2013) *Acta Neuropathol.*, 125, pp. 795-813.

- Wakade, C., Chong, R., Bradley, E., Thomas, B., Morgan, J.
Upregulation of GPR109A in Parkinson's disease
(2014) *PLoS ONE*, 9.

- Wang, Y.-M., Liu, Z.-Y., Ai, Y.-H., Zhang, L.-N., Zou, Y., Peng, Q.-Y.
Blocking the CD38/cADPR pathway plays a double-edged role in LPS stimulated microglia
(2017) *Neuroscience*, 361, pp. 34-42.

- Wardlaw, J.M., Benveniste, H., Nedergaard, M., Zlokovic, B.V., Mestre, H., Lee, H.
Perivascular spaces in the brain: anatomy, physiology and pathology
(2020) *Nat. Rev. Neurol.*, 16 (3), pp. 137-153.

- Wenning, G.K., Gilman, S., Seppi, K.
Second consensus statement on the diagnosis of multiple system atrophy
(2008) *Akt. Neurol.*, 35 (S 01), p. M394.

- Woollam, D.H., Millen, J.W.
The perivascular spaces of the mammalian central nervous system and their relation to the perineuronal and subarachnoid spaces
(1955) *J. Anat.*, 89 (2), pp. 193-200.

- Wyss-Coray, T.
Ageing, neurodegeneration and brain rejuvenation
(2016) *Nature*, 539 (7628), pp. 180-186.

- Yang, Q., Song, D., Qing, H.
Neural changes in Alzheimer's disease from circuit to molecule: perspective of optogenetics
(2017) *Neurosci. Biobehav Rev.*, 79, pp. 110-118.

- Yuan, M., Wang, Y., Wang, S., Huang, Z., Jin, F., Zou, Q., Li, J., Cai, Z.
Bioenergetic impairment in the neuro-glia-vascular unit: an emerging physiopathology during aging
(2021) *Aging Dis.*, 12, pp. 2080-2095.

- Zhang, W., Wang, T., Pei, Z.
Aggregated alpha-synuclein activates microglia: a process leading to disease progression in Parkinson's disease
(2005) *FASEB J.*, 19 (6), p. 533e542.

- Zhang, Y., Barres, B.A.
Astrocyte heterogeneity: an underappreciated topic in neurobiology
(2010) *Curr. Opin. Neurobiol.*, 20, pp. 588-594.

- Zhang, W., Phillips, K., Wielgus, A.R.
Neuromelanin activates microglia and induces degeneration of dopaminergic neurons: implications for progression of Parkinson's disease
(2011) *Neurotox. Res.*, 19 (1), p. 63e72.

- Zhu, X.-H., Lu, M., Lee, B.-Y., Ugurbil, K., Chen, W.
In vivo NAD assay reveals the intracellular NAD contents and redox state in healthy human brain and their age dependences
(2015) *Proc. Natl. Acad. Sci. USA*, 112, pp. 2876-2881.

- Zhou, Y., Song, W.M., Andhey, P.S., Swain, A., Levy, T., Miller, K.R.
Human and mouse single-nucleus transcriptomics reveal TREM2-dependent and TREM2-independent cellular responses in Alzheimer's disease
(2020) *Nat. Med.*, 26, pp. 131-142.

- Zhou, Y., Cai, J., Zhang, W., Gong, X., Yan, S., Zhang, K.
Impairment of the glymphatic pathway and putative meningeal lymphatic vessels in the aging human
(2020) *Ann. Neurol.*, 87 (3), pp. 357-369.

- Zou, W., Pu, T., Feng, W., Lu, M., Zheng, Y., Du, R.
Blocking meningeal lymphatic drainage aggravates Parkinson's disease-like pathology in mice overexpressing mutated alpha-synuclein
(2019) *Transl. Neurodegener.*, 8, p. 7.

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