

In summary, astrocytes are vital cell mediators for the cerebral homeostasis and play an important role in the pathophysiology and progression of a number of brain disorders. Every day, new evidence emerges to reveal that the glial cells are much more than supporting and nourishing cells in the brain. Thus, astrocytes are everything plus the glue.

ACKNOWLEDGMENTS

The National Institute of Health and the National Institute of Neurological Disorders and Stroke (NIH/NINDS; R01-NS070024), Consejo Nacional de Ciencia y Tecnologia (CONACyT; INFR2014-224359), Programa de Desarrollo del Personal Docente (PRODEP-Redes 2014).

REFERENCES

1. Nye JS. The Notch proteins. *Curr Biol* 1999;9:R118.
2. Barker AJ, Ullian EM. New roles for astrocytes in developing synaptic circuits. *Commun Integr Biol* 2008;1:207-11.
3. Ota Y, Zanetti AT, Hallock RM. The role of astrocytes in the regulation of synaptic plasticity and memory formation. *Neural Plast* 2013;2013:185463.
4. Pekny M, Pekna M. Astrocyte reactivity and reactive astrogliosis: costs and Benefits. *Physiol Rev* 2014;94:1077-98.
5. Barros LF. Metabolic signaling by lactate in the brain. *Trends Neurosci* 2013;36:396-404.
6. Halassa MM, Haydon PG. Integrated brain circuits: astrocytic networks modulate neuronal activity and behavior. *Annu Rev Physiol* 2010;72:335-55.
7. Seifert G, Steinhäuser C. Neuron-astrocyte signaling and epilepsy. *Exp Neurol* 2013;244:4-10.
8. Cabezas R, Avila M, Gonzalez J, El-Bachá RS, Báez E, García-Segura LM, Jurado Coronel JC, Capani F, Cardona-Gomez GP, Barreto GE. Astrocytic modulation of blood brain barrier: perspectives on Parkinson's disease. *Front Cell Neurosci* 2014;8:211.
9. Lundgaard I, Osório MJ, Kress BT, Sanggaard S, Nedergaard M. White matter astrocytes in health and disease. *Neuroscience* 2014;276:161-73.
10. Kang K, Lee SW, Han JE, Choi JW, Song MR. The complex morphology of reactive astrocytes controlled by fibroblast growth factor signaling. *Glia* 2014;62:1328-44.
11. Yao PS, Kang DZ, Lin RY, Ye B, Wang W, Ye ZC. Glutamate/glutamine metabolism coupling between astrocytes and glioma cells: neuroprotection and inhibition of glioma growth. *Biochem Biophys Res Commun* 2014;450:295-9.
12. Meyer RP, Gehlhaus M, Knoth R, Volk B. Expression and function of cytochrome p450 in brain drug metabolism. *Curr Drug Metab* 2007;8:297-306.
13. Gonzalez-Perez O, Gutierrez-Fernandez F, Lopez-Virgen V, Collas-Aguilar J, Quinones-Hinojosa A, Garcia-Verdugo JM. Immunological regulation of neurogenic niches in the adult brain. *Neuroscience* 2012;226:270-81.
14. Lo Vasco VR, Fabrizi C, Panetta B, Fumagalli L, Cocco L. Expression pattern and sub-cellular distribution of phosphoinositide specific phospholipase C enzymes after treatment with U-73122 in rat astrocytoma cells. *J Cell Biochem* 2010;110:1005-12.
15. Rivera-Zengotita M, Yachnis AT. Gliosis versus glioma?: don't grade until you know. *Adv Anat Pathol* 2012;19:239-49.
16. Anderová M, Kubinová S, Mazel T, Chvátal A, Eliasson C, Pekny M, Sykova E. Effect of elevated K(+), hypotonic stress, and cortical spreading depression on astrocyte swelling in GFAP-deficient mice. *Glia* 2001;35:189-203.
17. Jo S, Yarishkin O, Hwang YJ, Chun YE, Park M, Woo DH, Bae JY, Kim T, Lee J, Chun H, Park HJ, Lee da Y, Hong J, Kim HY, Oh SJ, Park SJ, Lee H, Yoon BE, Kim Y, Jeong Y, Shim I, Bae YC, Cho J, Kowall NW, Ryu H, Hwang E, Kim D, Lee CJ. GABA from reactive astrocytes impairs memory in mouse models of Alzheimer's disease. *Nat Med* 2014;20:886-96.
18. Tong CK, Alvarez-Buylla A. SnapShot: adult neurogenesis in the V-SVZ. *Neuron* 2014;81:220-220.e1.
19. Gonzalez-Perez O, Alvarez-Buylla A. Oligodendrogenesis in the subventricular zone and the role of epidermal growth factor. *Brain Res Rev* 2011;67:147-56.
20. Edgar N, Sibille E. A putative functional role for oligodendrocytes in mood regulation. *Transl Psychiatry* 2012;2:e109.
21. Seri B, García-Verdugo JM, McEwen BS, Alvarez-Buylla A. Astrocytes give rise to new neurons in the adult mammalian hippocampus. *J Neurosci* 2001;21:7153-60.
22. Prochnow N, Abdulazim A, Kurtenbach S, Wildförster V, Dvorianchikova G, Hanske J, Petrasch-Parwez E, Shestopalov VI, Dermietzel R, Manahan-Vaughan D, Zoidl G. Pannexin1 stabilizes synaptic plasticity and is needed for learning. *PLoS One* 2012;7:e51767.
23. Menn B, Garcia-Verdugo JM, Yaschine C, Gonzalez-Perez O, Rowitch D, Alvarez-Buylla A. Origin of oligodendrocytes in the subventricular zone of the adult brain. *J Neurosci* 2006;26:7907-18.
24. Deng Y, Xie D, Fang M, Zhu G, Chen C, Zeng H, Lu J, Charanjit K. Astrocyte-derived proinflammatory cytokines induce hypomyelination in the periventricular white matter in the hypoxic neonatal brain. *PLoS One* 2014;9:e87420.

Cite this article as: Gonzalez-Perez O, Lopez-Virgen V, Quiñones-Hinojosa A. Astrocytes: everything but the glue. *Neuroimmunol Neuroinflammation* 2015;2(2):115-7.

Source of Support: Nil. **Conflict of Interest:** No.

Received: 15-09-2014; **Accepted:** 10-11-2014