Chapter 1
Glial Cells in the Mature Central Nervous System: Classification and Functions

Kamal Smimih
Faculty of Sciences and Techniques, Sultan Moulay Slimane University, Morocco

Bilal El-Mansoury
https://orcid.org/0000-0002-2583-7515
Faculty of Sciences, University Chouaib Doukkali, Morocco

Chaima Azzouhri
Faculty of Sciences and Techniques, Sultan Moulay Slimane University, Morocco

Youssef Ait Hamdan
https://orcid.org/0009-0005-8616-8852
Higher Normal School, Cadi Ayyad University, Morocco

Fatima Ez-zahraa Saad
Faculty of Sciences, University Chouaib Doukkali, Morocco

Merzouki Mohamed
https://orcid.org/0000-0002-9837-4312
Faculty of Sciences and Techniques, Sultan Moulay Slimane University, Morocco

ABSTRACT

Glial cells were once thought of as simple support players in the central nervous system (CNS). However, the latest studies of glial cells have shown that they are actually of significance and play a variety of functions. Once thought to be passive supportive cells, astrocytes are now important in maintaining neurotransmitter balance, controlling synaptic activity, and regulating blood flow in the brain. Oligodendrocytes and Schwann cells, besides making myelin, are closely involved in controlling how fast nerve signals travel and maintaining the health of axons. Microglia had been thought to be only immune observers, but they also help to control the immune response and control synapses. Ependymal cells, which are sometimes ignored, are important in regulating cerebrospinal fluid circulation, directing the location of neural stem cells, and enabling cell communication. This chapter explores distinct glial cell types -astrocytes, oligodendrocytes, Schwann cells, microglia, and ependymal cells- highlighting their newfound, intricate functionalities and interactions with neurons.

DOI: 10.4018/978-1-6684-9675-6.ch001

INTRODUCTION

The intricate functioning of the nervous system is no longer attributed solely to neurons; the once-overlooked glial cells have taken center stage due to their vital contributions. Glial cells, which are often called "supporting cast" of neurons, have important roles to play in ensuring neuronal health, promoting communication, and influencing many aspects of brain function. Glial cells, or neuroglia, constitute a wide array of non-neuronal cells that make up the CNS and peripheral nervous system (PNS). Historically perceived as passive structural elements, glial cells are now recognized as active participants in neural circuits.

While neurons are renowned for their ability to transmit electrical signals, glial cells play a multifaceted role. Astrocytes, a prominent type of glial cell in the CNS, contribute to neurotransmitter regulation, maintenance of ion balance, and provision of metabolic support to neurons (Verkhratsky and Nedergaard 2018). Oligodendrocytes, on the other hand, specialize in myelination, crucial for rapid signal propagation (Saab et al. 2016). Microglia, the immune cells of the CNS, serve as sentinels, detecting and responding to pathogens or tissue damage (Kettenmann et al. 2011). Ependymal cells have been shown to actively participate in the circulation of cerebrospinal fluid and the maintenance of brain balance (Del Bigio 2010). These diverse roles differentiate glial cells from neurons and establish their importance in the intricate network of the nervous system.

The vital role that glial cells play in the neurological system is obscured by the typical focus on neurons. Neurotransmission, synaptic plasticity, and general brain homeostasis are all actively influenced by glial cells. Astrocytes regulate extracellular ion concentrations, optimizing synaptic transmission and preventing excitotoxicity (Khakh and Sofroniew 2015). Oligodendrocytes ensure rapid conduction through axonal myelination, enhancing the efficiency of neural communication (Fields 2015). Microglia, once thought solely to combat infections, are now understood to sculpt neural circuits, contributing to learning and memory processes (Parkhurst et al. 2013).

This chapter introduces glial cells and sheds insight on their recently discovered roles and functions as key players in the nervous system. It also makes the way for an exploration of the complex interactions that underlie neural function by looking at their differences from neurons and emphasizing their multifaceted activities.

TYPES OF GLIAL CELLS

Astrocytes Structure

The CNS contains astrocytes, a subclass of glial cells that support neural function and maintain neural homeostasis in many of ways. Morphologically, astrocytes typically exhibit a star-like shape, with a central cell body containing a nucleus and numerous radiating processes (Oberheim, Goldman, and Nedergaard 2012). These processes can be categorized into two major types: fibrous and protoplasmic (Bushong, Martone, and Ellisman 2004) (Figure 1). Fibrous astrocytes, predominantly found in white matter, have fewer, longer processes that align with axons, while protoplasmic astrocytes, located in gray matter, possess shorter, highly branched processes that interact extensively with neurons and synapses (Halassa et al. 2007).