Glial cell

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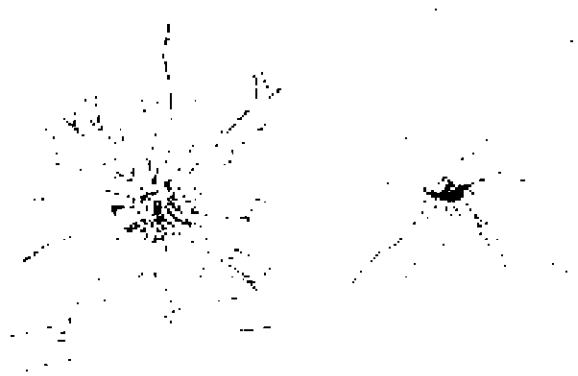

Neuroglia of the brain shown by Golgi's method.

Astrocytes can be visualized in culture because, unlike other mature glia, they express glial fibrillary acidic protein.

Glial cells, commonly called **neuroglia** or simply **glia** (greek for "glue"), are non-neuronal cells that provide support and nutrition, maintain homeostasis, form myelin, and participate in signal transmission in the nervous system. In the human brain, glia are estimated to outnumber neurons by about 10 to 1.[1]

Glial cells provide support and protection for neurons, the other main type of cell in the central nervous

system. They are thus known as the "glue" of the nervous system. The four main functions of glial cells are to surround neurons and hold them in place, to supply nutrients and oxygen to neurons, to insulate one neuron from another, and to destroy pathogens and remove dead neurons.

Contents

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[edit] Function of the glial cell

Some glia function primarily as physical support for neurons. Others regulate the internal environment of the brain, especially the fluid surrounding neurons and their synapses, and provide nutrition to nerve cells. Glia have important developmental roles, guiding migration of neurons in early development, and producing molecules that modify the growth of axons and dendrites. Recent findings in the hippocampus and cerebellum have indicated that glia are also active participants in synaptic transmission, regulating clearance of neurotransmitter from the synaptic cleft, releasing factors such as ATP which modulate presynaptic function, and even releasing neurotransmitters themselves.

Traditionally glia had been thought to lack certain features of neurons. For example, glia were not believed to have chemical synapses or to release neurotransmitters. They were considered to be the passive bystanders of neural transmission. However, recent studies disproved this. For example, astrocytes are crucial in clearance of neurotransmitter from within the synaptic cleft, which provides distinction between arrival of action potentials and prevents toxic build up of certain neurotransmitters such as glutamate (excitotoxicity). Furthermore, at least in vitro, astrocytes can release neurotransmitter glutamate in response to certain stimulation. Another unique type of glia, the oligodendrocyte precursor cells or OPCs, have very well defined and functional synapses from at least two major groups of

neurons. The only notable differences between neurons and glia, by modern scrutiny, are the ability to generate action potentials and the polarity of neurons, namely the axons and dendrites which glia lack. It is inappropriate nowadays to consider glia as 'glue' in the nervous system as the name implies. They are also crucial in the development of the nervous system and in processes such as synaptic plasticity and synaptogenesis.

Glia have a role in the regulation of repair of neurons after injury. In the CNS glia suppress repair. Astrocytes enlarge and proliferate to form a scar and produce myelin and inhibitory molecules that inhibit regrowth of a damaged or severed axon. In the PNS Schwann cells promote repair. After axon injury Schwann cells regress to an earlier developmental state to encourage regrowth of the axon. This difference between PNS and CNS raises hopes for the regeneration of nervous tissue in the CNS, for example a spinal cord injury or severance.

[edit] Types of glia

[edit] Microglia

For more details on this topic, see Microglia.

Microglia are specialized macrophages capable of phagocytosis that protect neurons of the central nervous system. Though not technically glia because they are derived from hemopoietic precursors rather than ectodermal tissue, they are commonly categorized as such because of their supportive role to neurons.

These cells comprise approximately 15% of the total cells of the central nervous system. They are found in all regions of the brain and spinal cord. Microglial cells are small relative to macroglial cells, with changing shapes and oblong nuclei. They are mobile within the brain and multiply when the brain is damaged. In the healthy central nervous system, microglia processes constantly sample all aspects of their environment (neurons, macroglia and blood vessels).

[edit] Macroglia

Location Name	Description

CNS	Astrocytes	The most abundant type of glial cell, *astrocytes* (also called *astroglia*) have numerous projections that anchor neurons to their blood supply. They regulate the external chemical environment of neurons by removing excess ions, notably potassium, and recycling neurotransmitters released during synaptic transmission. The current theory suggests that astrocytes may be the predominant "building blocks" of the blood-brain barrier. Astrocytes may regulate vasoconstriction and vasodilation by producing substances such as arachidonic acid, whose metabolites are vasoactive. Astrocytes signal each other using calcium. The gap junctions (also known as electrical synapses) between astrocytes allow the messenger molecule IP3 to diffuse from one astrocyte to another. IP3 activates calcium channels on cellular organelles, releasing calcium into the cytoplasm. This calcium may stimulate the production of more IP3. The net effect is a calcium wave that propagates from cell to cell. Extracellular release of ATP, and consequent activation of purinergic receptors on other astrocytes, may also mediate calcium waves in some cases. There are generally two types of astrocytes, protoplasmic and fibrous, similar in function but distinct in morphology and distribution. Protoplasmic astrocytes have short, thick, highly branched processes and are typically found in gray matter. Fibrous astrocytes have long, thin, less branched processes and are more commonly found in white matter.
CNS	Oligodendrocytes	*Oligodendrocytes* are cells that coat axons in the central nervous system (CNS) with their cell membrane, called myelin, producing the so-called myelin sheath. The myelin sheath provides insulation to the axon that allows electrical signals to propagate more efficiently.
CNS	Ependymal cells	*Ependymal cells*, also named *ependymocytes*, line the cavities of the CNS and make up the walls of the ventricles. These cells create and secrete cerebrospinal fluid(CSF) and beat their cilia to help circulate that CSF.
CNS	Radial glia	*Radial glia cells* arise from neuroepithelial cells after the onset of neurogenesis. Their differentiation abilities are more restricted than those of neuroepithelial cells. In the developing nervous system, radial glia function both as neuronal progenitors and as a scaffold upon which newborn neurons migrate. In the mature brain, the cerebellum and retina retain characteristic radial glial cells. In the cerebellum, these are Bergmann glia, which regulate synaptic plasticity. In the retina, the radial Müller cell is the principal glial cell, and participates in a bidirectional communication with neurons.

PNS	Schwann cells	Similar in function to oligodendrocytes, *Schwann cells* provide myelination to axons in the peripheral nervous system (PNS). They also have phagocytotic activity and clear cellular debris that allows for regrowth of PNS neurons.
PNS	Satellite cells	*Satellite cells* are small cells that line the exterior surface of PNS neurons and help regulate the external chemical environment.

[edit] Capacity to divide

Glia retain the ability to undergo cell division in adulthood, while most neurons cannot. The view is based on the general deficiency of the mature nervous system in replacing neurons after an insult or injury, such as a stroke or trauma, while very often there is a profound proliferation of glia, or gliosis near or at the site of damage. However, detailed studies found no evidence that 'mature' glia, such as astrocytes or oligodendrocytes, retain the ability of mitosis. Only the resident oligodendrocyte precursor cells seem to keep this ability after the nervous system matures. On the other hand, there are a few regions in the mature nervous system, such as the dentate gyrus of the hippocampus and the subventricular zone, where generation of new neurons can be observed.

[edit] Embryological development

Most glia are derived from ectodermal tissue of the developing embryo, particularly the neural tube and crest. The exception is microglia, which are derived from hemopoietic stem cells. In the adult, microglia are largely a self-renewing population and are distinct from macrophages and monocytes which infiltrate the injured and diseased CNS.

In the central nervous system, glia develop from the ventricular zone of the neural tube. These glia include the oligodendrocytes, ependymal cells, and astrocytes. In the peripheral nervous system, glia derive from the neural crest. These PNS glia include Schwann cells in nerves and satellite cells in ganglia.

[edit] History

Glia were discovered in 1856 by the pathologist Rudolf Virchow in his search for a 'connective tissue' in the brain.

The human brain contains about ten times more glial cells than neurons. [1] Following its discovery in the late 19th century, this fact underwent significant media distortion, emerging as the famous myth claiming that "we are using only 10% of our brain". The role of glial cells as managers of

communications in the synapse gap, thus modifying learning pace, has been discovered only very recently (2004).

[edit] Additional images

Oligodendrocyte

Section of central canal of medulla spinalis, showing ependymal and neuroglial cells.

Transverse section of a cerebellar folium.

[edit] References

1. ^ *a* *b* sfn.org Society for Neuroscience, 2000

[edit] External links

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- New Source of Replacement Brain Cells Found - glial cells can transform into other cell types and reproduce indefinitely — tricks once thought exclusive to stem cells.

- Artist ADSkyler(uses concepts of neuroscience and found inspiration from Glia)

v • d • e

Histology: nervous tissue [hide]

Neurons (gray matter)	soma, axon (axon hillock, axoplasm, axolemma, neurofibril/neurofilament), dendrite (Nissl body, dendritic spine) *types* (bipolar, pseudounipolar, multipolar, pyramidal, Purkinje, granule)
Afferent nerve/Sensory nerve/Sensory neuron	GSA, GVA, SSA, SVA, *fibers* Ia, Ib or Golgi, II or Aβ, III or Aδ or fast pain, IV or C or slow pain
Efferent nerve/Motor nerve/Motor neuron	GSE, GVE, SVE, Upper motor neuron, Lower motor neuron (Aα motorneuron, Aγ motorneuron)
Synapses	neuropil, synaptic vesicle, neuromuscular junction, electrical synapse - Interneuron (Renshaw)
Sensory receptors	Free nerve ending, Meissner's corpuscle, Merkel nerve ending, Muscle spindle, Pacinian corpuscle, Ruffini ending, Olfactory receptor neuron, Photoreceptor cell, Hair cell, Taste bud
Glial cells	astrocyte, oligodendrocyte, ependymal cells, microglia, radial glia
Myelination (white matter)	Schwann cell, oligodendrocyte, nodes of Ranvier, internode, Schmidt-Lanterman incisures, neurolemma
Related connective tissues	epineurium, perineurium, endoneurium, nerve fascicle, meninges

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