White matter tract

A neural pathway that serves to connect relatively distant areas of the brain or nervous system is usually a bundle of neurons, known collectively as white matter. A neural pathway that spans a shorter distance between structures, such as most of the pathways of the major neurotransmitter systems, is usually called grey matter.

see Fascicle

see Motor tract

see Corticospinal tract.

see Spinothalamic tract.

The description of human white matter pathways experienced a tremendous improvement, thanks to the advancement of neuroimaging and dissection techniques. The downside of this progress is the production of redundant and conflicting literature, bound by specific studies' methods and aims. The Superior Longitudinal System (SLS), encompassing the arcuate (AF) and the superior longitudinal fasciculi (SLF), becomes an illustrative example of this fundamental issue, being one of the most studied white matter association pathways of the brain. Vavassori et al. provided a complete illustration of this white matter fiber system's current definition, from its early descriptions in the nineteenth century to its most recent characterizations. They proposed a review of both in vivo diffusion magnetic resonance imaging-based tractography and anatomical dissection studies, enclosing all the information available up to date. Based on these findings, they reconstructed the wiring diagram of the SLS, highlighting a substantial variability in the description of its cortical sites of termination and the taxonomy and partonomy that characterize the system. They aimed to level up discrepancies in the literature by proposing a parallel across the various nomenclature. Consistent with the topographical arrangement already documented for commissural and projection pathways, they suggested approaching the SLS organization as an orderly and continuous wiring diagram, respecting a medio-lateral palisading topography between the different frontal, parietal, occipital, and temporal gyri rather than in terms of individualized fascicles. A better and complete description of the fine organization of white matter association pathways' connectivity is fundamental for a better understanding of brain function and their clinical and neurosurgical applications [1).].

History

During the 1930s, white matter tracts began to assume relevance for neurosurgery, especially after Cajal's work. In many reviews of white matter neurobiology, the seminal contributions of Josef Klingler (1888-1963) and their neurological applications have been overlooked. In 1934 at the University of Basel under Eugen Ludwig, Klingler developed a new method of dissection based on a freezing technique for brain tissue that eloquently revealed the white matter tracts. Klingler worked with anatomists, surgeons, and other scientists, and his models and dissections of white matter tracts remain arguably the most elegant ever created. He stressed 3-dimensional anatomic relationships and laid the foundation for defining mesial temporal, limbic, insular, and thalamic fiber and functional relationships and contributed to the potential of stereotactic neurosurgery. Around 1947, Klingler was part of a Swiss-German group that independently performed the first stereotactic thalamotomies, basing their targeting and logic on Klingler's white matter studies, describing various applications of stereotaxy and showing Klingler's work integrated into a craniocerebral topographic system for targeting with external localization of eloquent brain structures and stimulation of deep thalamic nuclei. Klingler's work has received renewed interest because it is applicable for correlating the results of the fiber-mapping paradigms from diffusion tensor imaging to actual anatomic evidence. Although others have described white matter tracts, none have had as much practical impact on neuroscience as Klinger's work. More importantly, Josef Klingler was an encouraging mentor, influencing neurosurgeons, neuroscientists, and brain imaging for more than three quarters of a century [2)].

The first named pathways are evident to the naked eye even in a poorly preserved brain, and were named by the great anatomists of the Renaissance using cadaver material. Examples of these include the great commissures of the brain such as the corpus callosum (Latin, “hard body”; not to be confused with the Latin word “colossus” - the “huge” statue), anterior commissure, and posterior commissure. Further examples of this (by no means a complete list) include the pyramidal tract, crus cerebri (Latin, “leg of the brain”), and cerebellar peduncles (Latin, “little foot of the cerebellum”). Note that these names describe the appearance of a structure but give one no information on its function or location.

Later, as neuroanatomical knowledge became more sophisticated, the trend was toward naming pathways by their origin and termination. For example, the nigrostriatal pathway, which is degenerated in Parkinson's disease, runs from the substantia nigra (Latin, “black substance”) to the corpus striatum (Latin, “striped body”). This naming can extend to include any number of structures in a pathway, such that the cerebellorubrothalamocortical pathway originates in the cerebellum, synapses in the red nucleus (“ruber” in Latin), on to the thalamus, and finally terminating in the cerebral cortex.

Sometimes, these two naming conventions coexist. For example, the name “pyramidal tract” has been mainly supplanted by lateral corticospinal tract in most texts. Note that the “old” name was primarily descriptive, evoking the pyramids of antiquity, from the appearance of this neural pathway in the medulla oblongata. The “new” name is based primarily on its origin (in the primary motor cortex, Brodmann area 4) and termination (onto the alpha motor neurons of the spinal cord).

Functional aspects[edit] In general, neurons receive information either at their dendrites or cell bodies. The axon of a nerve cell is, in general, responsible for transmitting information over a relatively long distance. Therefore, most neural pathways are made up of axons. the pathway will appear a darker beige color, which is generally called grey (British English, or gray in American English).

Some neurons are responsible for conveying information over long distances. For example, motor neurons, which travel from the spinal cord to the muscle, can have axons up to a meter in length in humans; the longest axon in the human body is almost two meters long in tall individuals and runs from the great toe to the medulla oblongata of the brainstem. These are archetypical examples of neural pathways.

Major neural pathways

Arcuate fasciculus

Cerebral peduncle

Corpus callosum

Pyramidal or corticospinal tract

Dopamine pathways:

Mesocortical pathway

Mesolimbic pathway.

Nigrostriatal pathway

Tuberoinfundibular pathway

Diffuse low grade glioma [DLGG]) is an infiltrative brain tumor that usually migrates along the white matter tracts.

Imaging

White matter tracts can be observed using tractograms generated from diffusion tensor imaging (DTI).

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Vavassori L, Sarubbo S, Petit L. Hodology of the superior longitudinal system of the human brain: a historical perspective, the current controversies, and a proposal. Brain Struct Funct. 2021 Apr 21. doi: 10.1007/s00429-021-02265-0. Epub ahead of print. PMID: 33881634.
2)
Agrawal A, Kapfhammer JP, Kress A, Wichers H, Deep A, Feindel W, Sonntag VK, Spetzler RF, Preul MC. Josef Klingler's models of white matter tracts: influences on neuroanatomy, neurosurgery, and neuroimaging. Neurosurgery. 2011 Aug;69(2):238-52; discussion 252-4. doi: 10.1227/NEU.0b013e318214ab79. PubMed PMID: 21368687.