

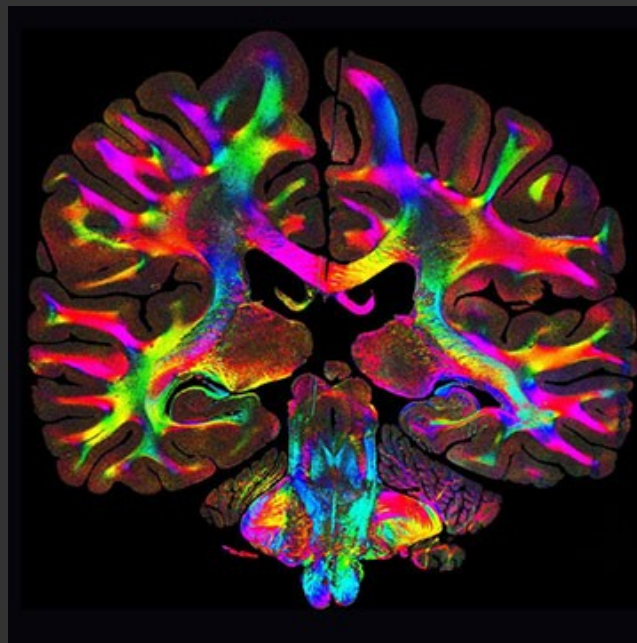
Brain Imaging Reveals the Glymphatic System

by Fey Adelstein, December 2025

Insight Into Brain Structure

The extension of human sight by way of technology provides us newly observed realities. When the first photographs of the earth from space were published, it inspired a vision of our planet as a whole and complex self-balancing system. Likewise, innovations in imaging offer new perspectives from which to better understand our physiology.

Images of the human brain are obtained by a variety of methods. The image below of a preserved brain (Georgiadis et al., 2025)ⁱ was made using computational scattered light imaging (ComSLI) and a rotating LED light source.



Technological invention also provides us opportunities to observe a living brain in real time, gathering further details of its structures and functions. The discussion below describes the ground breaking discovery known as the Glymphatic System, made by Maiken Nedergaard in 2012.

Imaging Technologies Reveal Fluid Flows

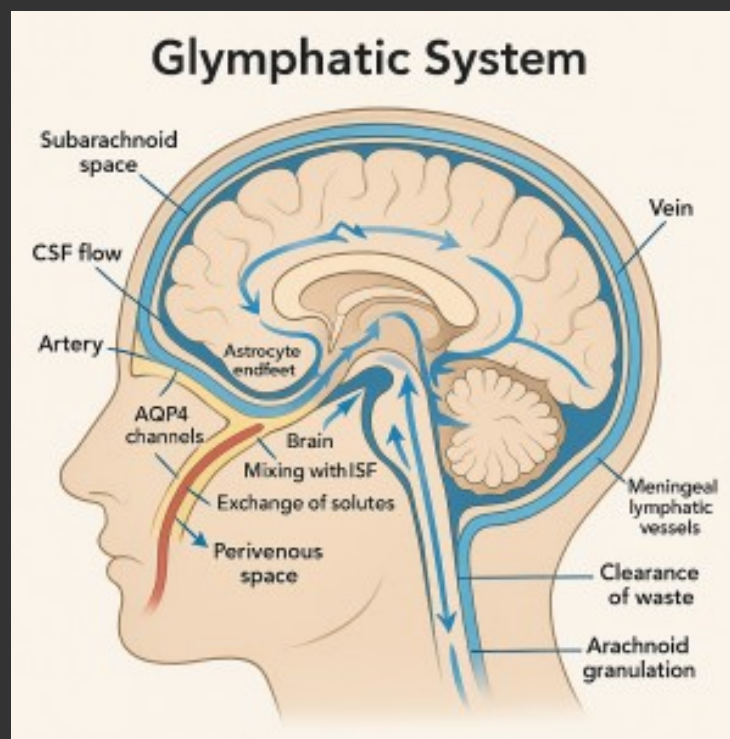
The Glymphatic systemⁱⁱ (Jensen et al., 2015) was discovered by Maiken Nedergaard and her team at the University of Rochester.ⁱⁱⁱ (Nedergaard et al., 2012). Her discovery was made using Two-photon excitation microscopy (TPEF or 2PEF), a pulsed laser technology used together with the injection of fluorescent tracers. Nedergaard's first observations of Glymphatic flows were made of living mice. Later the Glymphatic System was confirmed to also exist in humans, made visible by way of Magnetic Resonance Imaging (MRI).

What is the Glymphatic System?

By way of these real time images and recordings, researchers are able to look inside the brain to watch the channeling of fluids regulated by Glial cells. Glial cells perform multiple roles including: protecting neurons, controlling the transport of fluids, and regulating the sleep-wake cycle. Nedergaard named the Glymphatic System after the Glial cells and the Lymphatic System, which is part of the immune system.

The Brain's Special Requirements and Sleep's Critical Role in Brain Health

Because of its high energy consumption and high demand for nutrients, the brain produces a lot of waste products. These wastes need to be removed in a timely manner for the brain to function properly. The removal of metabolites and proteins is sometimes described as the brain washing^{iv} itself. This wash cycle of the Glymphatic system is activated during sleep, and its observation has taught us a lot about the importance of sleep for brain health. Sleep is when the brain detoxes itself in preparation for the day ahead.



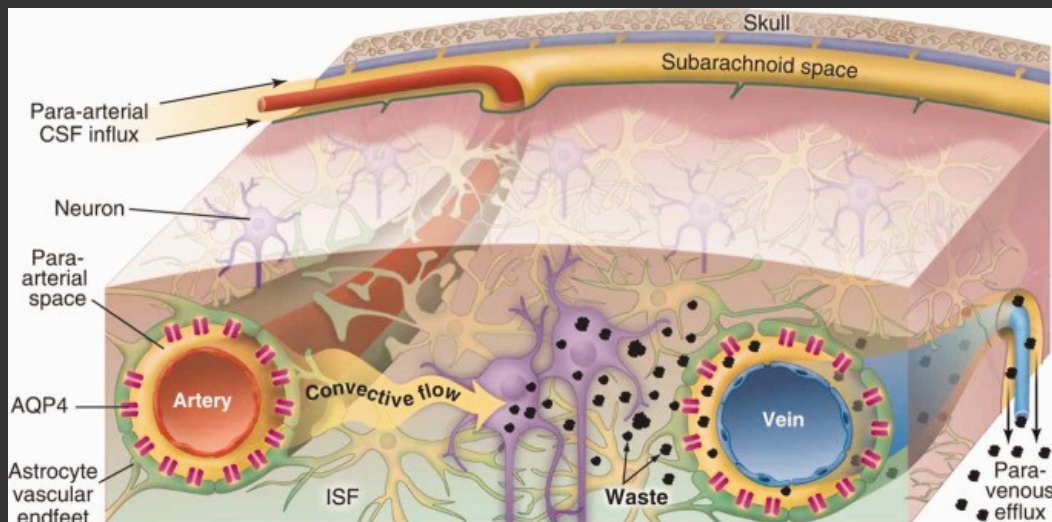
Cerebral Spinal Fluid (CSF).

In other organs of the body, the process of delivering nutrients and removing wastes is performed by the blood and lymphatic system. However in the brain, the blood vessel infrastructure is unique: arteries are spaced at a greater distance from veins, which facilitates servicing the brain with Cerebral Spinal Fluid (CSF). Nedergaard's discovery revealed the process by which CSF collects wastes, carries these wastes into veins and transports them out of the brain and into the Lymphatic System, which then further transports them to the liver to be processed. (Image 2.^v depicts the direction of flow of Cerebral Spinal Fluid in the brain.)

Propulsion by Arterial Pulses

Vessels carrying CSF are located alongside blood vessels (perivascular space^{vi}) so that pulses driving blood simultaneously propel CSF through the brain. The force of the pulses is transferred to the CSF which is mixed with Interstitial Fluids (ISF) as it is perfused through brain tissues. (Image 3.^{vii}

Illustrates the convective flow of CSF and mixing with ISF as facilitated by aquaporin-4 water channels.)



Slow Synchronized Waves

Further observations of the brain during sleep have been made by Electroencephalography, which records the electrical impulses of the brain. In the sleep state, slow electrical brain waves are propagated. These are known as: delta (0.5–4 Hz), theta (6–10 Hz), spindle (12–15 Hz) and ripple (140–200 Hz).^{viii} “All are all well-orchestrated and temporally coupled with each other.”^{ix} It is thus demonstrated that in the sleep state, neurons synchronize to these slower brain waves, and this waveform organization amplifies the fluid flows of the Glymphatic System.

Another Driver: EZ Fueled by Infrared

In addition to the heart driven pulses, a discovery made by Gerard Pollack of a boundary along the arteries reveals the existence of a complementary propelling force in the blood vessels. Pollack’s observation of what he calls the Exclusion Zone (EZ) includes a “surface-induced flow, originating in the blood vessels themselves”. His discovery demonstrates that infrared energy is the “fuel for this second driving mechanism”.^x

VIDEO [Maiken Nedergaard](https://www.youtube.com/watch?v=He6HMnMbxAc) presents her discovery of the Glymphatic System, Youtube <https://www.youtube.com/watch?v=He6HMnMbxAc>

Medical Disclaimer: nothing in this article is intended to be medical advice. The author is not a licensed medical practitioner.

Lifestyle Habits For Optimal Glymphatic Clearance:

- Quality sleep
- Meditation and somatic modalities that reduce stress
- Exercise, and specifically rebounding/bouncing or aerobic exercise to stimulate lymphatic flow
- Nose Breathing to invigorate the sinus area adjacent to lymph drainage
- Lymphatic massage , and skin brushing
- Adequate hydration and Anti-inflammatory Diet
- PEMF
- Charging the body’s EZ water by way of sunlight or infrared light

i Image 1. Georgiadis, M., *et al.* (2025). Micron-resolution fiber mapping in histology independent of sample preparation, *Nature Communications*, 16, Article number: 9572. <https://www.nature.com/articles/s41467-025-64896-9>

ii Jessen, N.A., Munk, A.S.F., Lundgaard, I., & Nedergaard, M. (2015). **The Glymphatic System: A Beginner's Guide**. *Neurochem Res* **40**, 2583–2599. <https://doi.org/10.1007/s11064-015-1581-6>

iii Maiken N. *et al.* (2012). **A Paravascular Pathway Facilitates CSF Flow Through the Brain Parenchyma and the Clearance of Interstitial Solutes, Including Amyloid β** . *Sci Transl Med*. Aug 15;4(147):147ra111. doi: [10.1126/scitranslmed.3003748](https://doi.org/10.1126/scitranslmed.3003748)

iv Hamilton, J. (2024). **The Brain Makes a Lot of Waste. Now Scientists Think They Know Where it Goes**, <https://www.npr.org/sections/shots-health-news/2024/06/26/g-s1-6177/brain-waste-removal-system-amyloid-alzheimer-toxins>

v Image 2. Source: <https://willowsclinic.com/the-glymphatic-system-explained-brain-detox-sleep-and-the-perrin-technique/>

vi Yamamoto, E. A. *et al.* (2024). **The Perivascular Space is a Conduit for Cerebrospinal Fluid Flow in Humans: A Proof-of-Principle Report**. *PNAS Highlights: Proceedings of the National Academy of Sciences of The United States of America*. Oct 7;121(42):e2407246121. doi: [10.1073/pnas.2407246121](https://doi.org/10.1073/pnas.2407246121)

vii Kilkilhati, T. *et al.* (2021). **Achieving brain clearance and preventing neurodegenerative diseases—A glymphatic perspective**. *Journal of Cerebral Blood flow & Metabolism*. 41(9):2137–2149. doi: <https://doi.org/10.1177/0271678X20982388>

viii Jiang-Xie, L.F. *et al.* (2024). **Neuronal Dynamics Direct Cerebrospinal Fluid Perfusion and Brain Clearance**. *Nature* **627**, 157–164 (2024). <https://doi.org/10.1038/s41586-024-07108-6> <https://www.nature.com/articles/s41586-024-07108-6.epdf>

ix Ibid

x Zheng Li, Z. & Pollack, G.H., (2023). **Discovering and Studying Exclusion Zone Water (EZ) Water Lining the Arteries**. *PLoS ONE* 18(10): e0289652. <https://doi.org/10.1371/journal.pone.0289652>. <https://doi.org/10.1371/journal.pone.0289652> <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0289652>

additional resources:

Dr Jocker's: video on the Glymphatic System <https://www.youtube.com/watch?v=N4ZfXDdRdG0>

Dr Jocker's: article on the Glymphatic System <https://drjockers.com/glymphatic-system/>