BIOCHEMISTRY OF NERVOUS SYSTEM I

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Advance Clinical Biochemistry II (MA 406)

Summer Semester

Lecture Three

19/08/2025

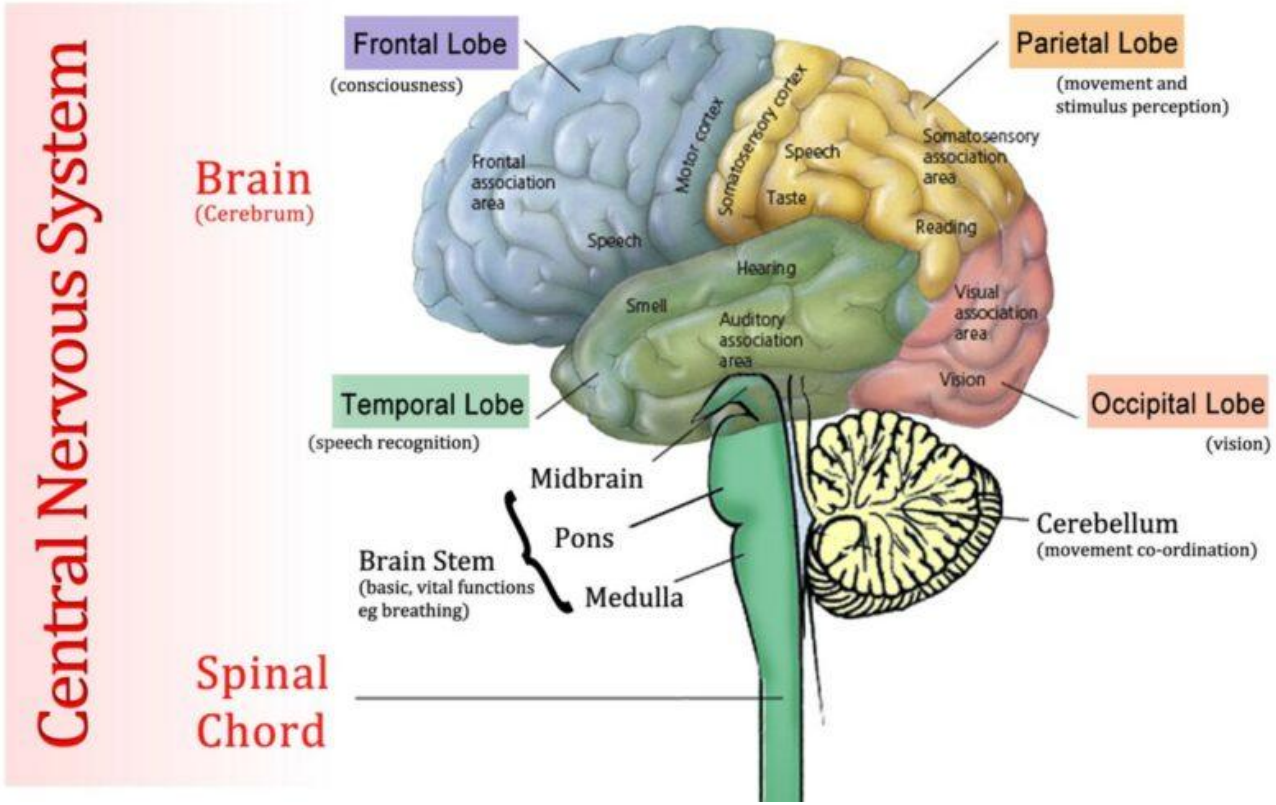
Outlines

- CNS and CSF
- Transport of substances through the BBB
- Metabolism of neurotransmitters
- Synthesis of neurotransmitters
- Release of neurotransmitters
- Effect of neurotransmitters
- Termination of neurotransmitters

Objectives

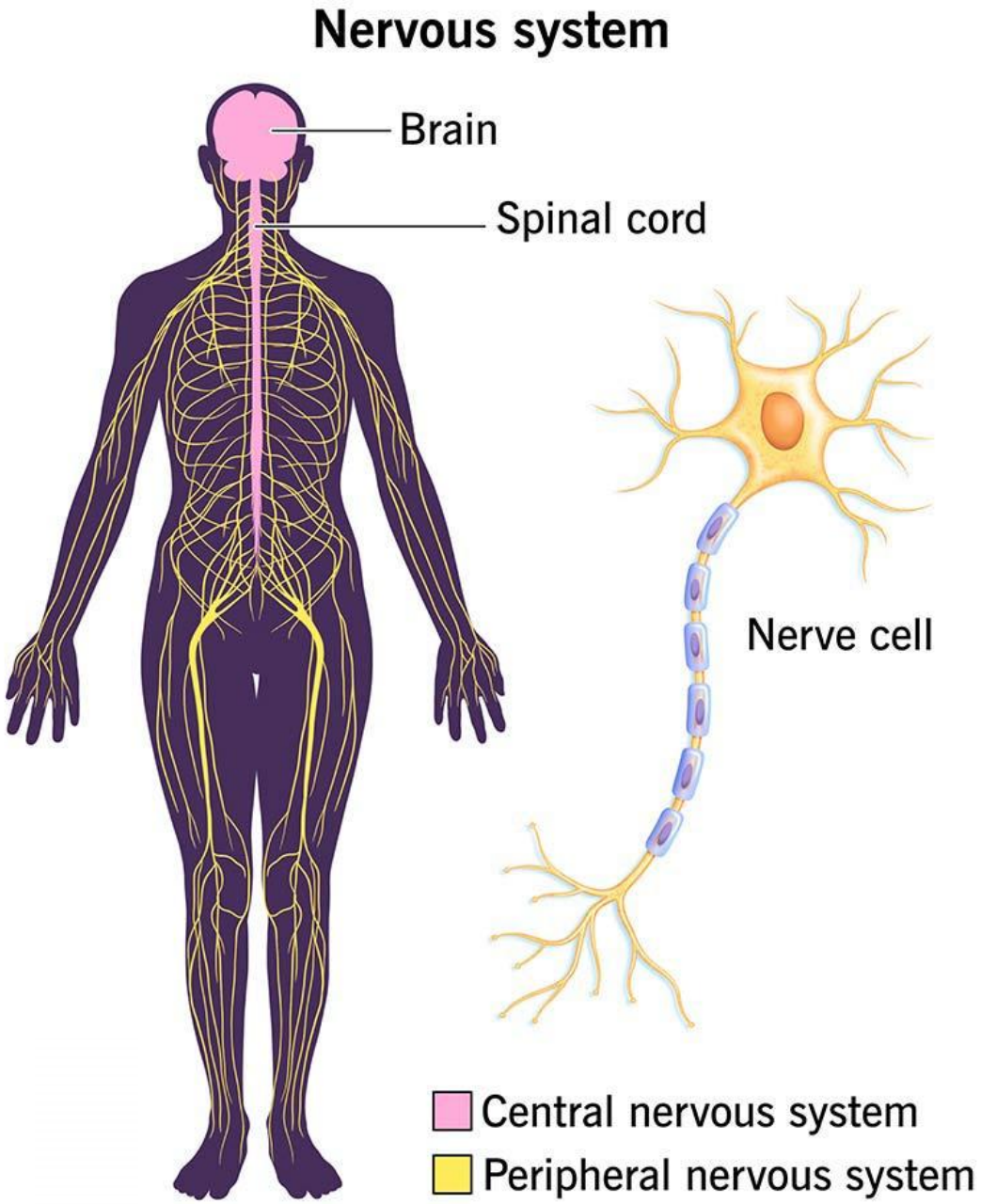
- **At the end of this lesson, the students should be able to:**

- Understand the general concept of the nervous system.
- Understand the biochemistry behind the workings of the nervous system.
- Understand how neurotransmitters are synthesized.



Introduction

- Many neurological disorders have a biochemical basis or are associated with disturbances of metabolism.
- The study of the biochemical basis of diseases affecting CNS and PNS is termed neurochemistry.
- Many generalized disorders of metabolism affect the CNS.

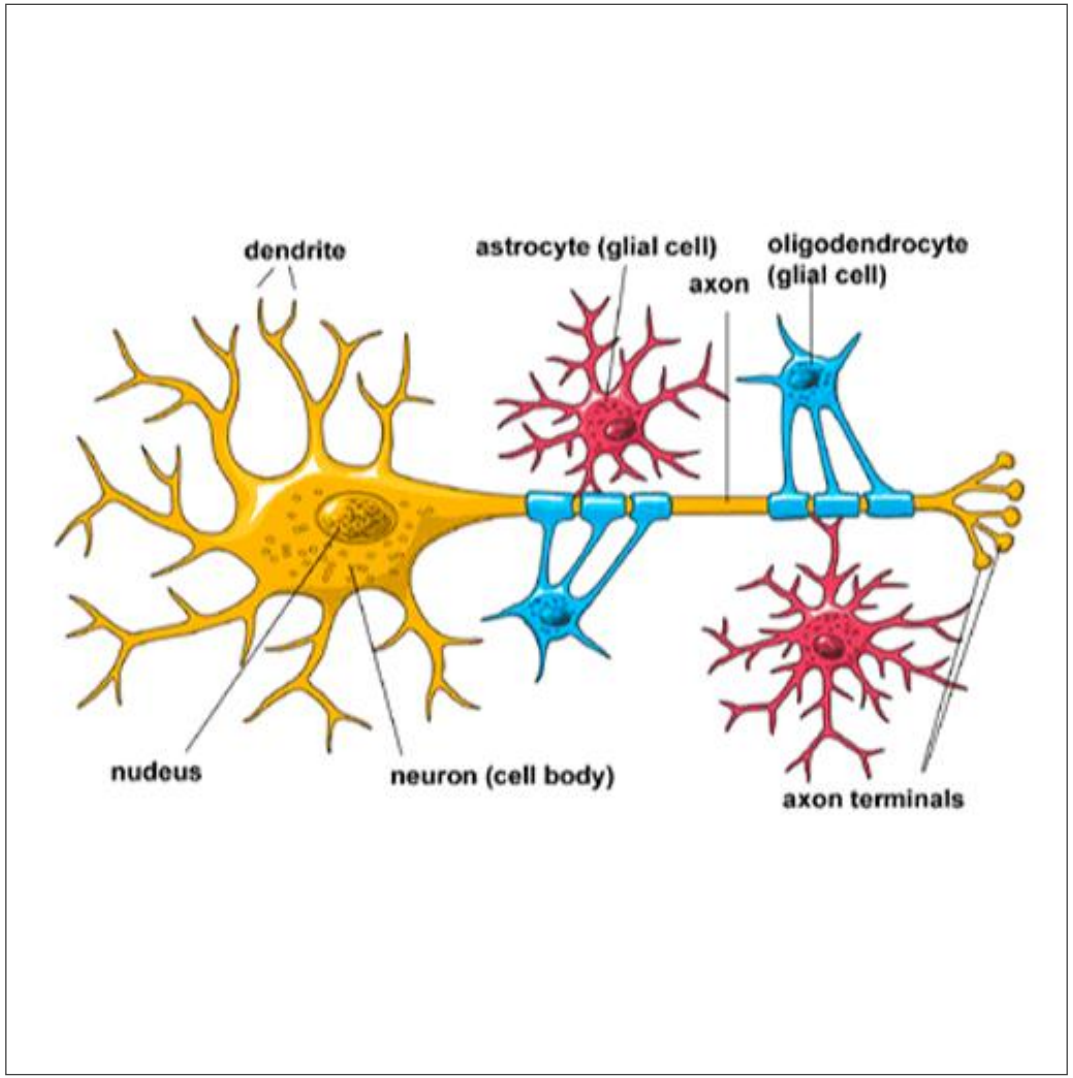


Nervous system

- The human nervous system comprises two main parts **Central and Peripheral Nervous System)**:

- **CNS**: This includes the brain and spinal cord. The CNS is responsible for processing information, coordinating responses, and controlling voluntary and involuntary actions.

- **PNS**: This consists of nerve fibers that connect the CNS to every other part of the body. It includes motor neurons (for voluntary movement) and the autonomic nervous system (which regulates involuntary activities).

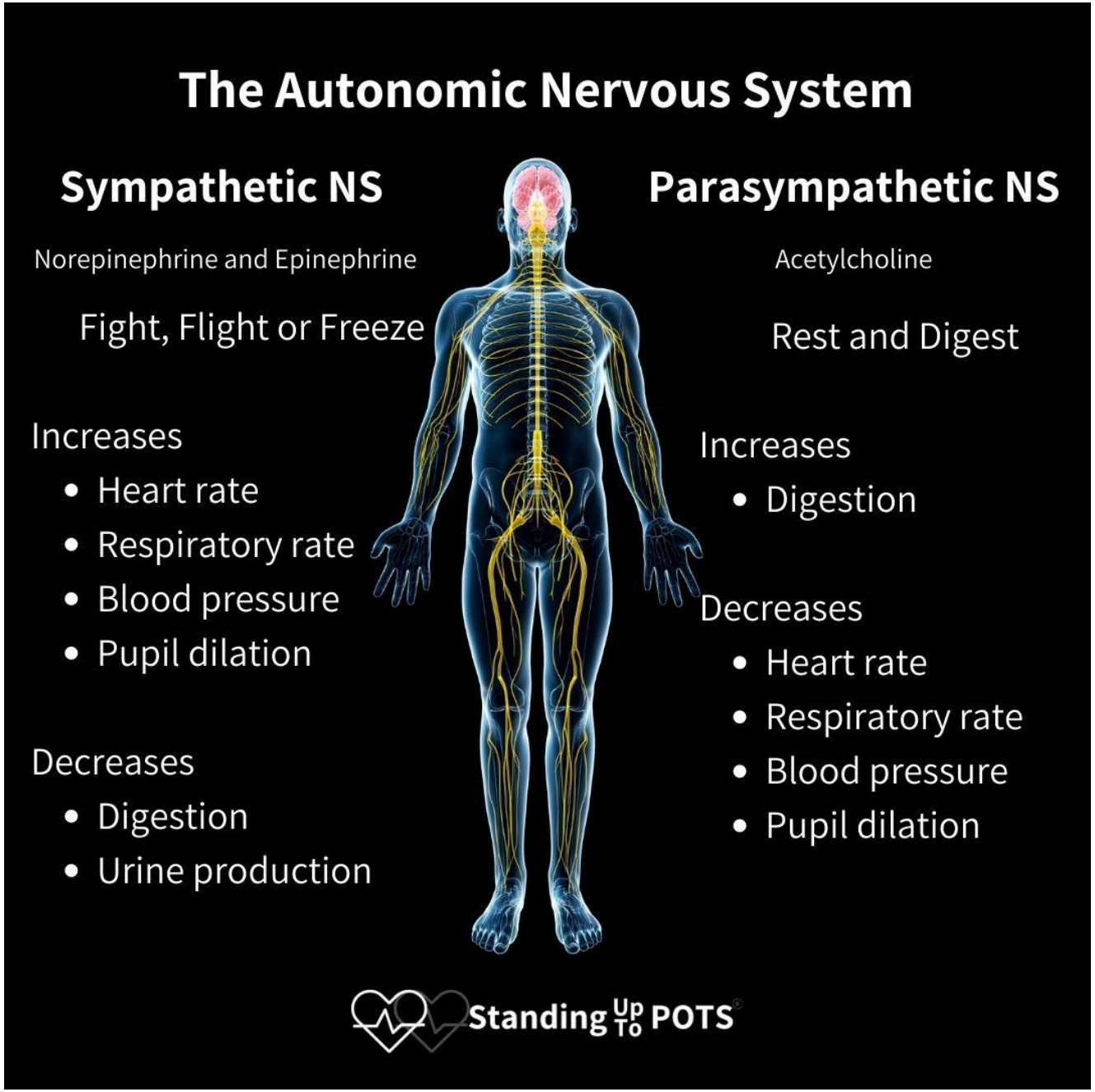


Neurons and Glia Cells

- **Neurons**: These specialized cells transmit chemical signals in nerve transmission.

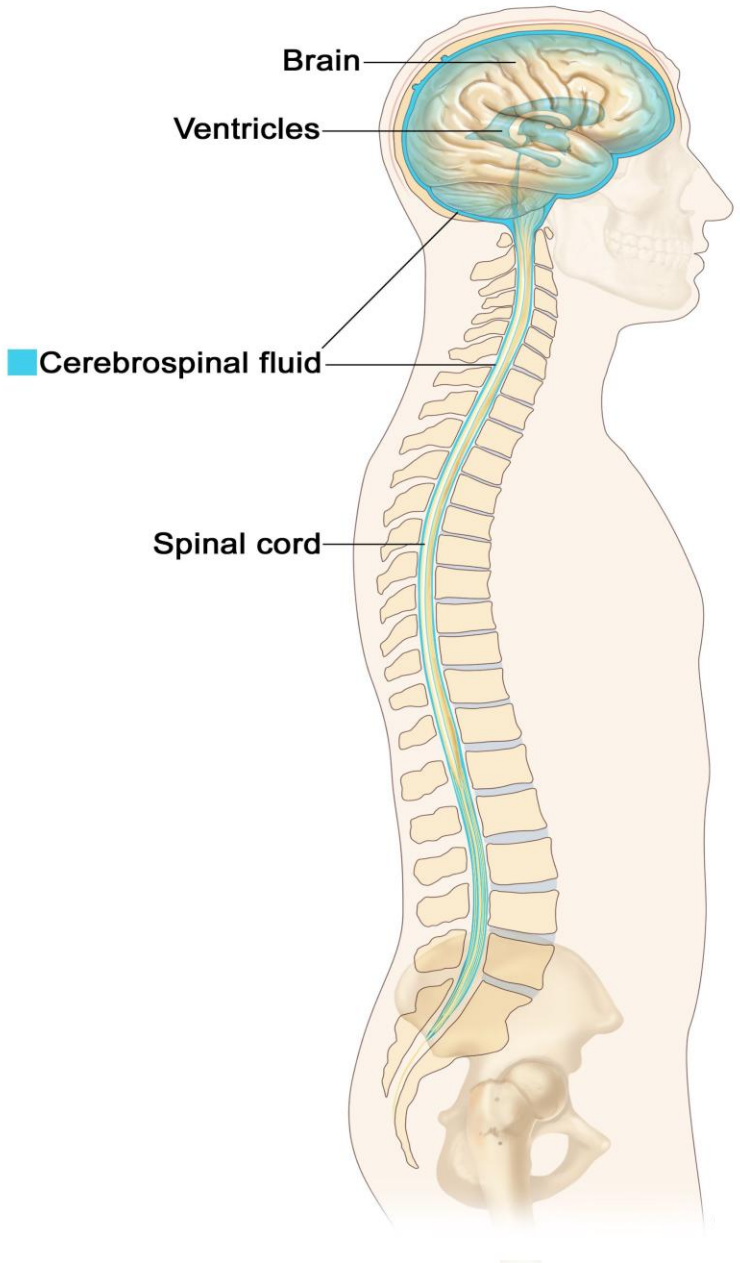
- They play a crucial role in communication within the nervous system.

- **Glial Cells**: These cells support and protect neurons. They are essential for maintaining the health and function of the nervous system.



Autonomic Nervous System

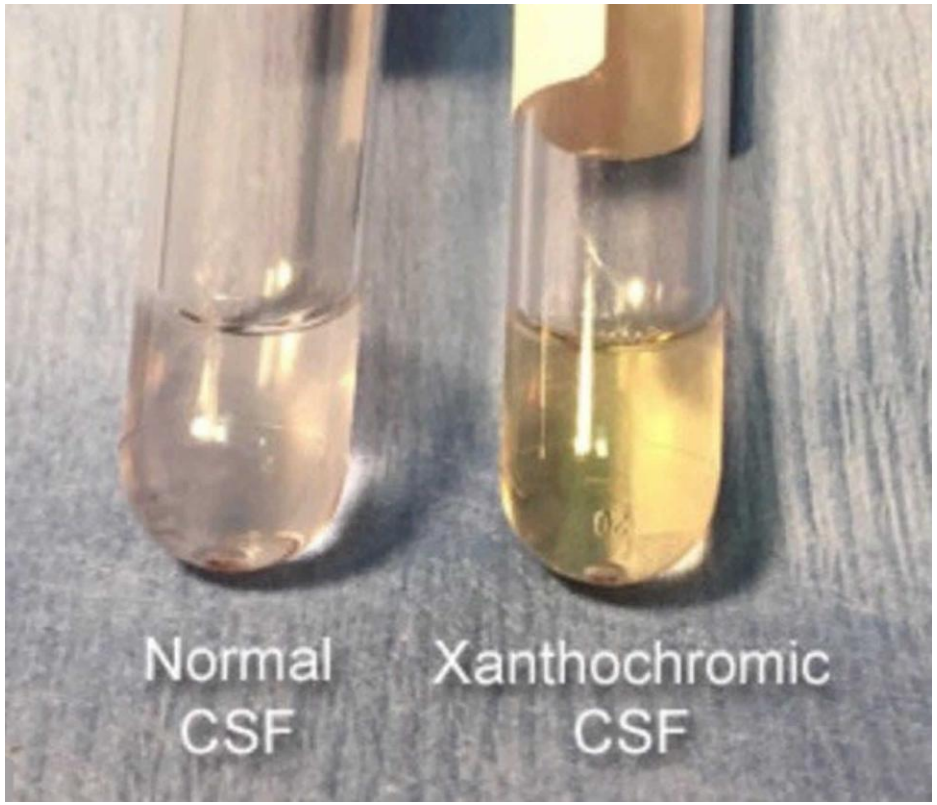
- The autonomic nervous system controls involuntary activities, and it includes:
- **Sympathetic Nervous System**: Responsible for the “fight or flight” response.
- **Parasympathetic Nervous System**: Involved in relaxation and energy conservation.
- **Enteric Nervous System**: Semi-independent, regulating gastrointestinal processes.



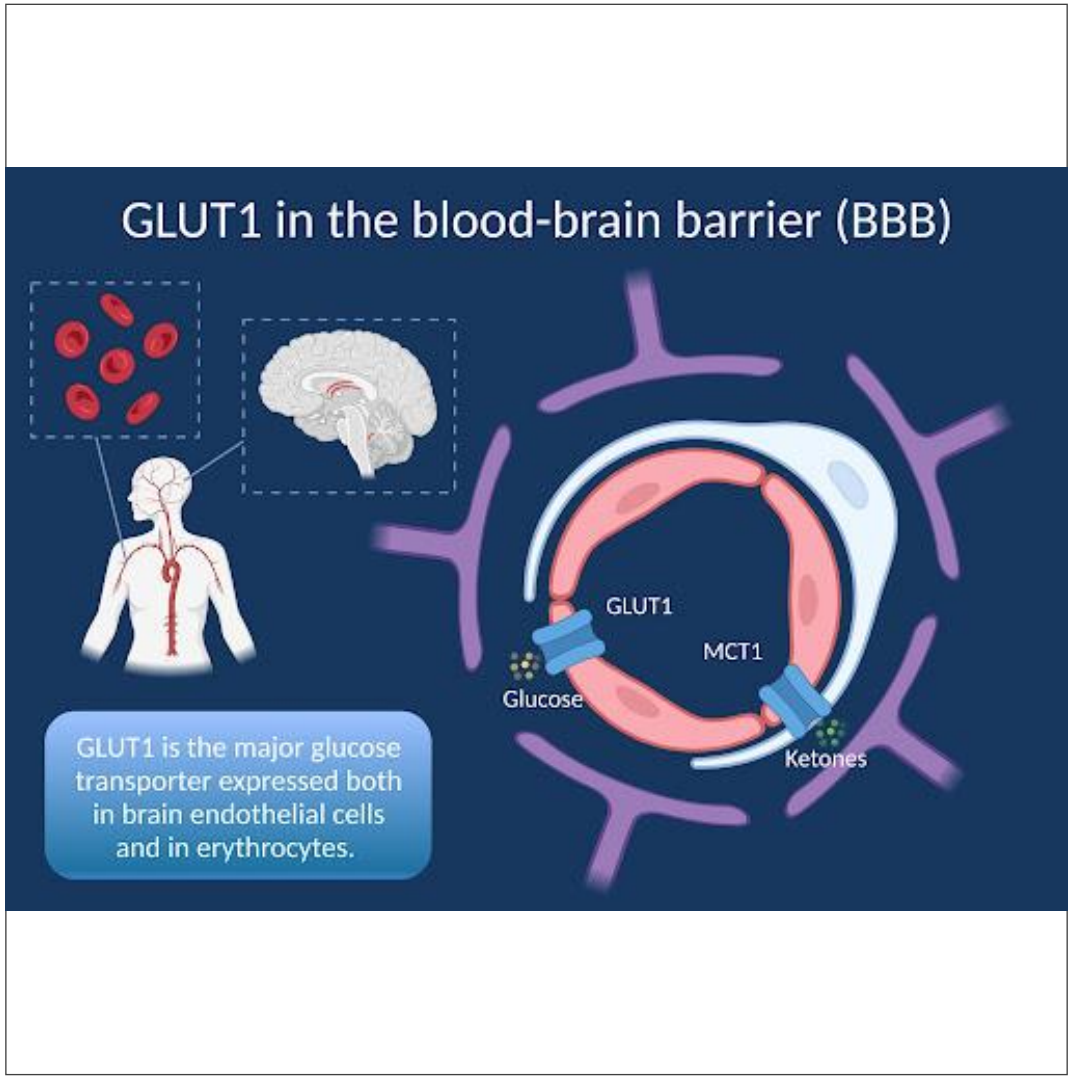
Cerebrospinal fluid

- **CSF** is a clear, colorless fluid found within the tissue that surrounds the brain & spinal cord of all vertebrates.
- **CSF** (blue) is made by tissue that lines the ventricles (hollow spaces) in the brain.
- It flows in and around the brain and spinal cord to help cushion them from injury and provide nutrients.

Appearance of CSF

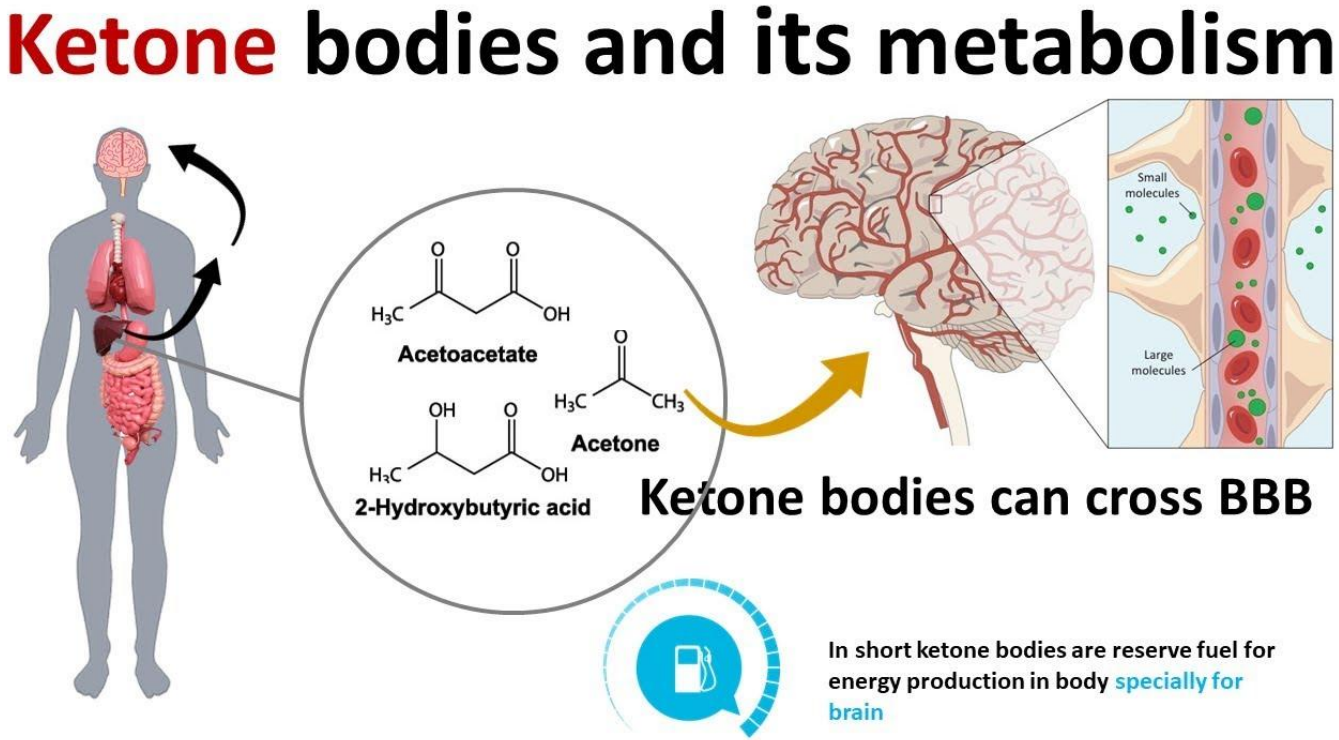


- CSF is normally clear and colorless. Turbidity is usually due to leucocytes, but it may be due to microorganisms.
- Blood-stained CSF may indicate a recent hemorrhage or damage to a blood vessel during specimen collection.
- Xanthochromia (yellow color) is most often due to previous hemorrhage into the CSF, but it may indicate high protein in CSF.
- The CSF may be yellow in jaundiced patients.



Transport through BBB

- A large number of compounds are transported through endothelial capillaries by facilitated diffusion.
- Fuels Glucose: The principal fuel of the brain is transported through endothelial membranes by facilitated diffusion via GLUT-1.
- At blood glucose of 60 m/dl, glucose is reduced to below Km of GLUT-1 leading to the appearance of symptoms of hypoglycemia



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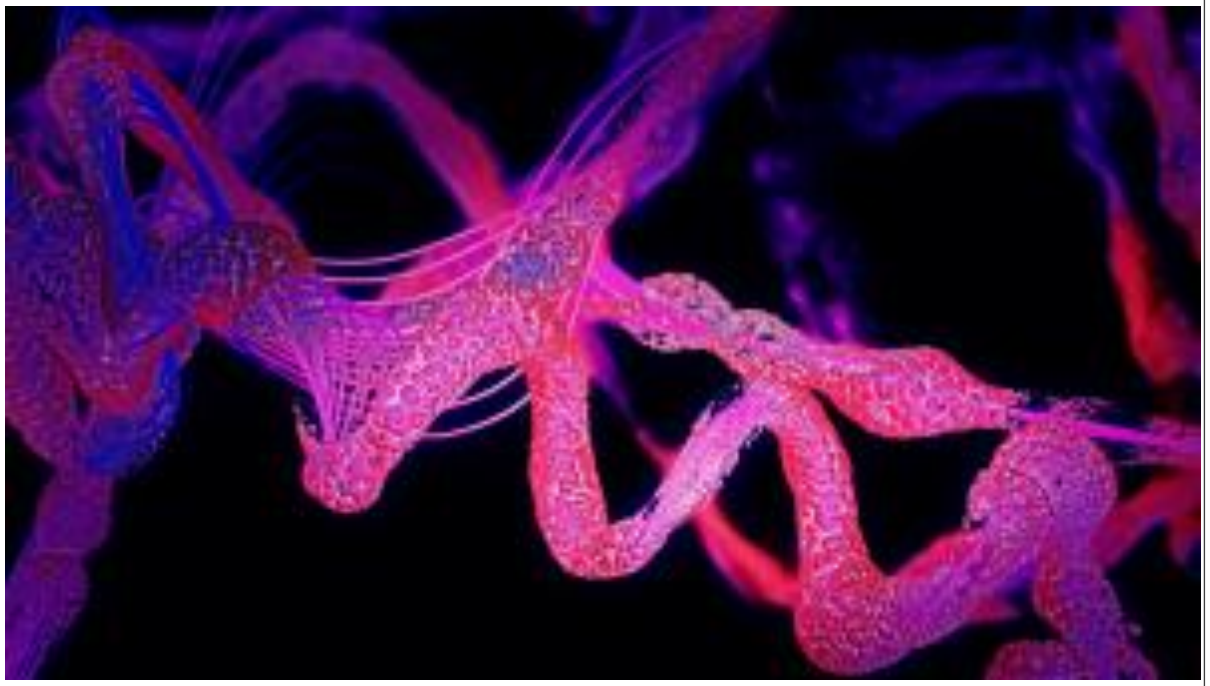
- Others: as ketone bodies by another transport system When blood levels of KB are elevated (during starvation).
- KBs are important fuels for the brain during prolonged starvation Non-essential fatty acids (of diet or lipolysis) do not cross BBB
- Essential fatty acids (linoleic & linolenic) can pass BBB



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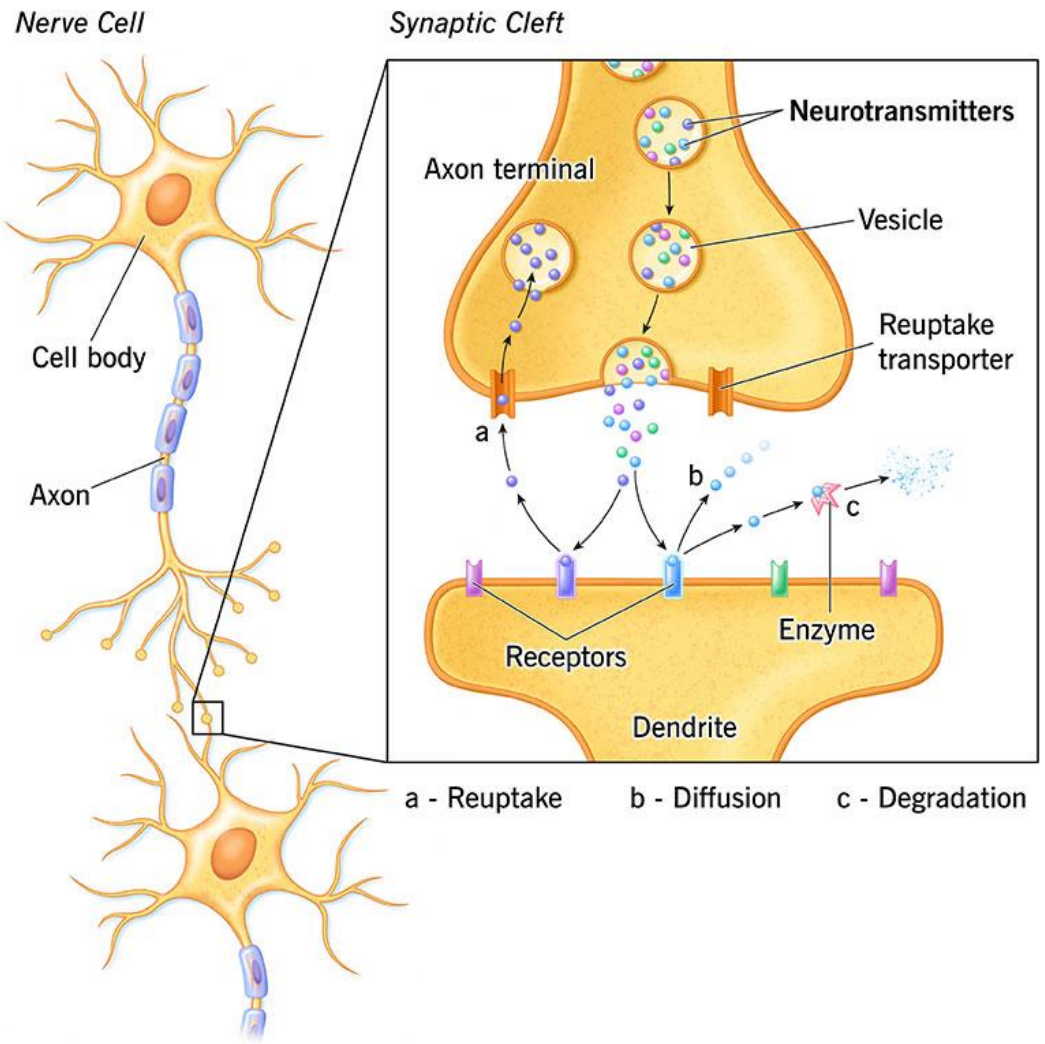
- Amino acids are transported by amino acid transporters, and are used in the brain for the synthesis of:
- Proteins of CNS and Neurotransmitters.

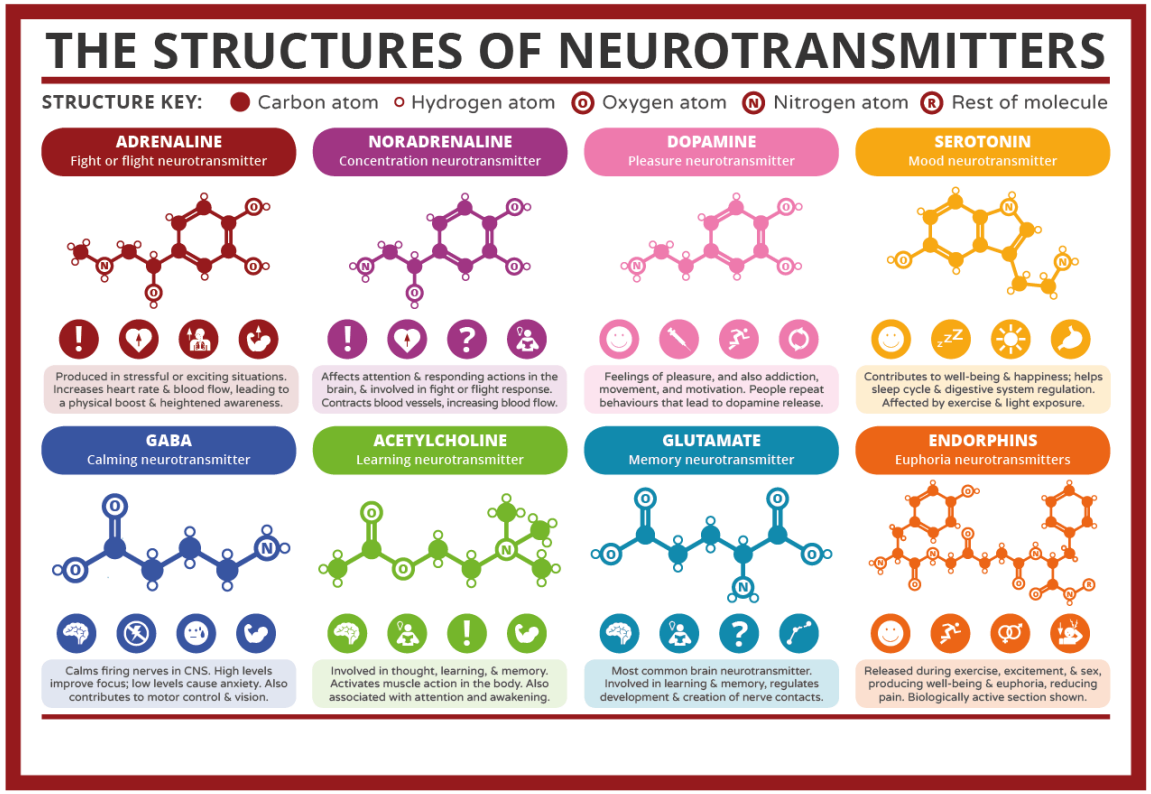
- Types of transported amino acids:
- Long neutral amino acids (by single amino acid transporters). Essential: Phe, Leu, Isoleucine, Val, Try, Met.

- Small neutral amino acids (entry is markedly restricted as their influx markedly changes the content of neurotransmitters). Nonessential: Alanine, Glycine, Proline



Metabolism of Neurotransmitters

- Neurotransmitters are chemicals released at synapses for the transmission of nerve impulses.
- Generally, each neuron synthesizes only those neurotransmitters that it uses for transmission through synapses.
- The neuronal tracts are often identified by their neurotransmitters.



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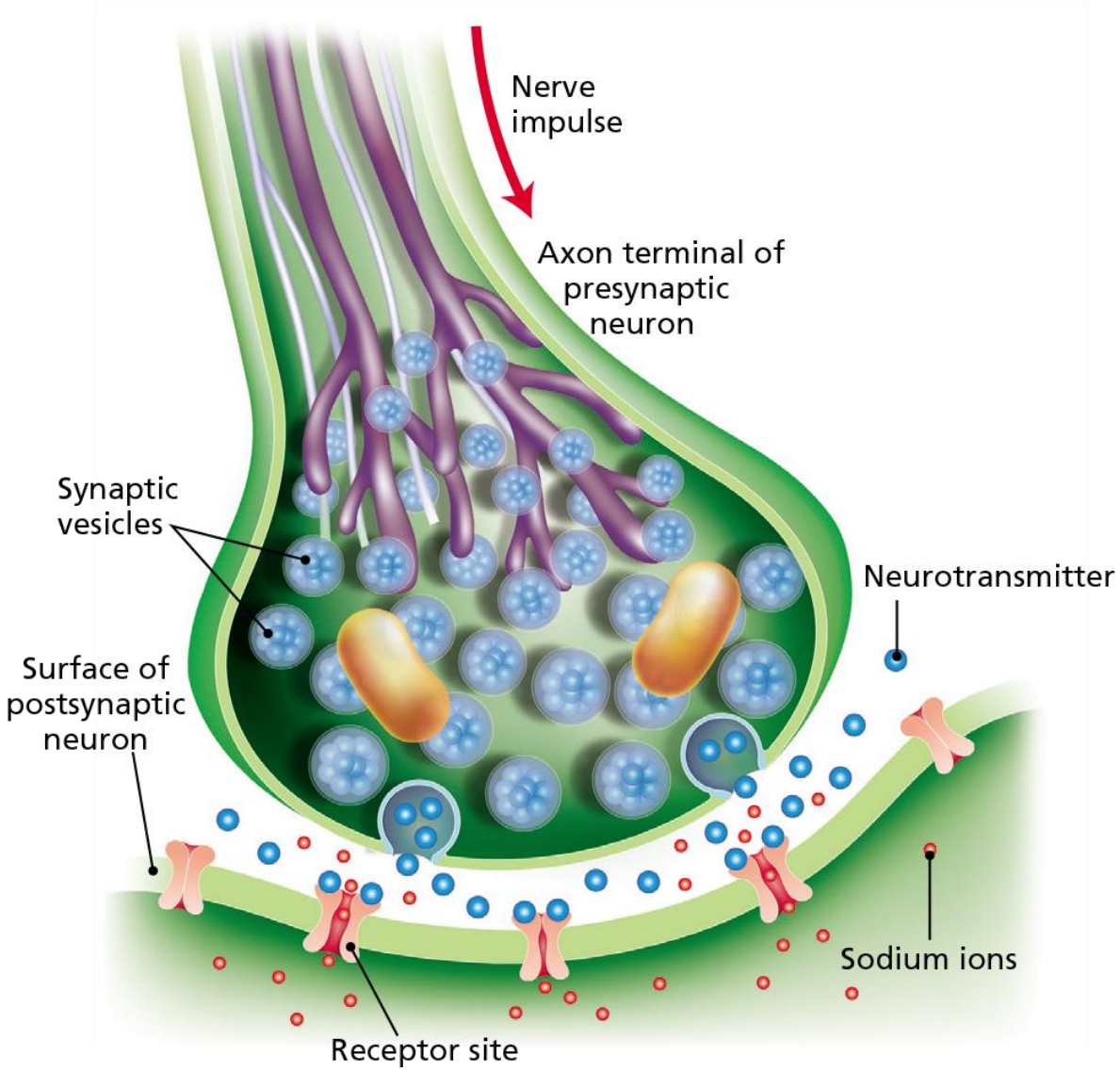
- Structurally neurotransmitters are divided into two categories:

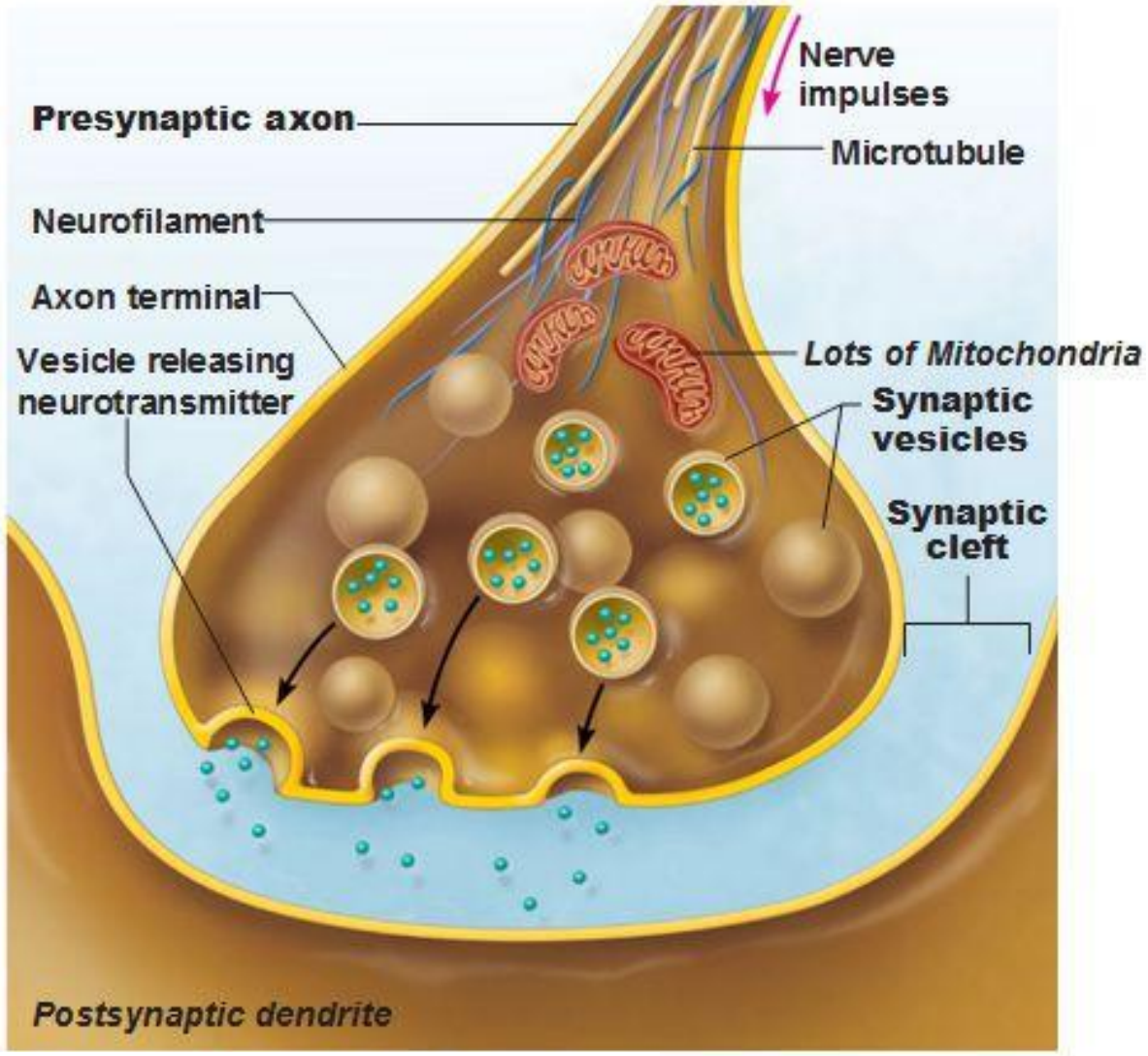
- Small nitrogen-containing neurotransmitters, e.g., neuropeptides (Targeted in CNS as endorphins or Released to circulation as GH & TSH.

- Major small nitrogen-containing neurotransmitters such as Glutamate, GABA, Glycine, Acetylcholine, Dopamine, Norepinephrine, Serotonin, Histamine, In addition to epinephrine, aspartate, nitric oxide



Neurotransmitter synthesis

- Neurotransmitters are mostly synthesized in the presynaptic terminal.
- They are synthesized from amino acids, Intermediates of glycolysis, and Intermediates of TCA.
- Once synthesized, they are stored in vesicles (by active uptake)



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- Neurotransmitters are released in response to nerve impulses which causes an influx of Ca^{2+} to the presynaptic terminal.
- neurotransmitters undergo exocytosis into synaptic cleft and binds to receptors on the postsynaptic membrane to elicit action.
- They also undergo termination through reuptake from the presynaptic terminal (or by glial cells) Or/ Enzymatic inactivation (in the pre or postsynaptic terminals)

Summary

- This lecture introduces the biochemistry of the nervous system, focusing on the structure and function of the central and peripheral nervous systems, neurons, and glial cells.
- It highlights the role of CSF in cushioning and nourishing the brain and spinal cord, and explains how its appearance can indicate underlying disease.
- The lecture further emphasizes the selective transport of substances across the BBB, with glucose as the primary fuel, ketone bodies as alternative energy sources, and amino acids as precursors for protein and neurotransmitter synthesis.
- It also describes neurotransmitter metabolism, including their synthesis from amino acids and metabolic intermediates, storage, release via calcium-dependent exocytosis, receptor binding, and termination through reuptake or enzymatic inactivation.
- The biochemical basis of neurological disorders is linked to disturbances in these processes, underscoring the clinical relevance of neurochemistry.

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Biochemistry of the Nervous System II


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