Physiology of Synaptic Transmission

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Objectives

- At the end of this lecture the student should :
- (1) define synapses and show where they are located .
- (2) describe the parts of a synapse , & what does each part contain .
- (3) know how to classify synapses .
- (4) define synaptic transmitters , give examples of excitatory & inhibitory ones ; explain how they are released
- (5) explain ionic channels that mediate actions on synaptic receptors .
- (6) explain : EPSP , IPSP , LTP .
- (7) describe properties of synapses such as convergence , divergence , spatial & temporal sunmmation , subliminal fringe , types of inhibition and their physiological significance .
- (8) expalin how acidosis and alkalosis can affect synaptic transmission

- Reference

- Ganong Review of Medical physiology, 23rd edition. Barret et al (eds) . Mc Graw Hill , Boston 2010 .
- Page 115 onward .

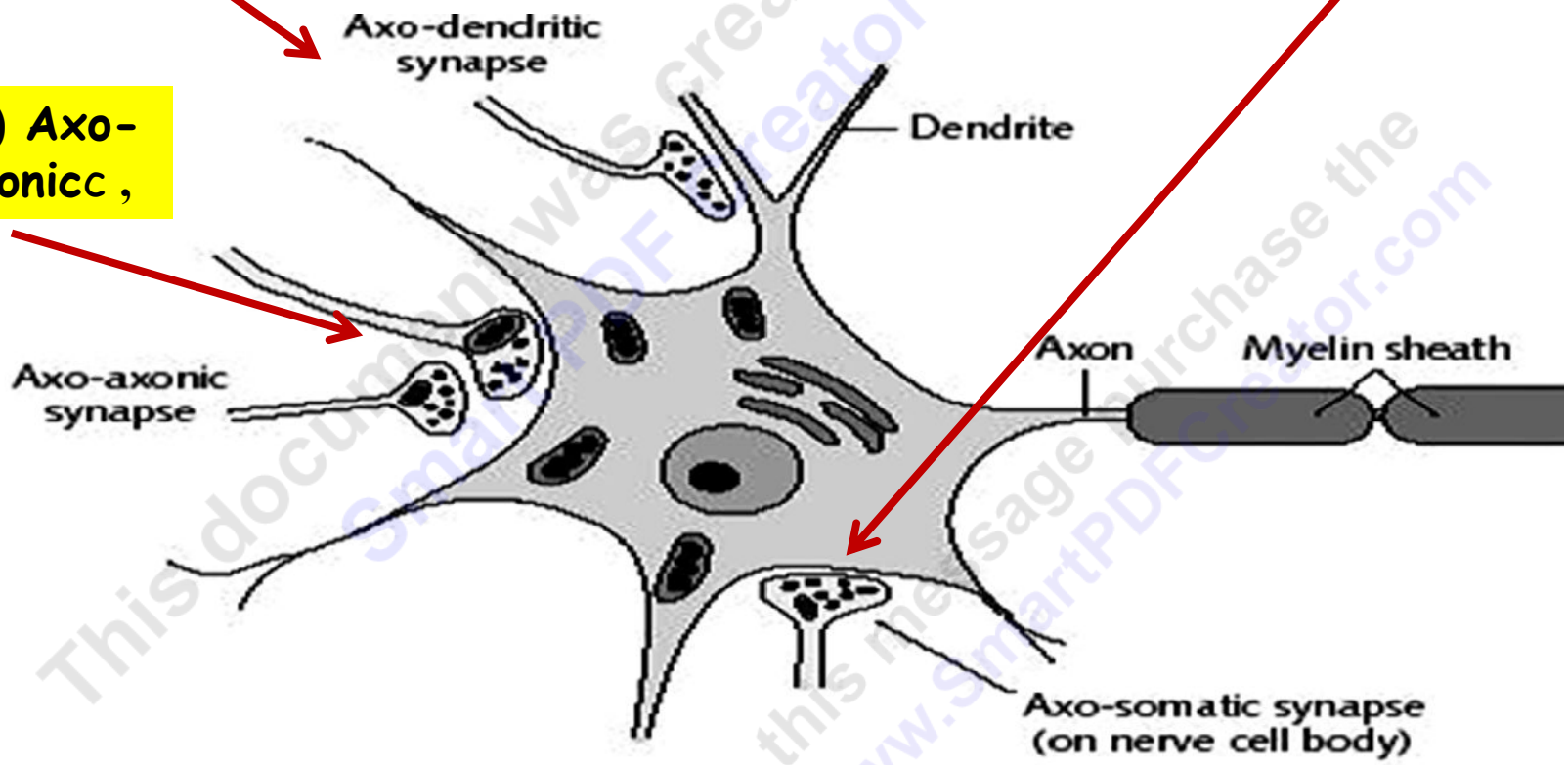
- What are synapses ?
- Where are they located ?
- What does each part of synapse contain ?

Classification of Synapses

(1) Axo-dendritic ,

(2) Axo-somatic ,

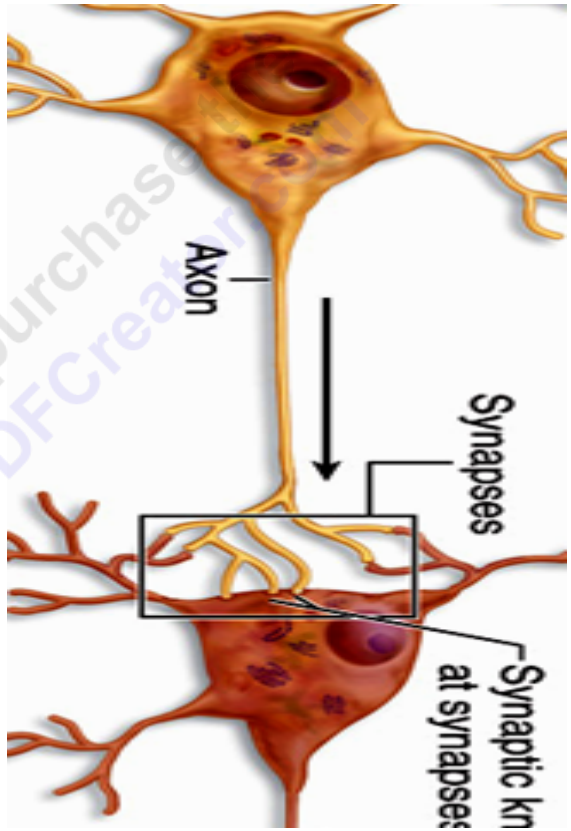
(3) Axo-axonicc ,



& less commonly →
(4) Dendro-somatic
(5) Somato-somatic

What is a neurotransmitter ?

- A neurotransmitter is a chemical substances that is released by a neuron (called presynaptic cell) , crosses the synaptic cleft , and binds to a receptor located on the membrane of another cell (called postsynaptic cell ;
- ✓ & the membrane of this postsynaptic neuron is called called postsynaptic membrane)



Q : What are the types of transmitters ?

- Excitatory neurotransmitter :

  a transmitter that produces excitatory postsynaptic potential (EPSP) on the postsynaptic neuron .
- Inhibitory neurotransmitter :

  a transmitter that produces inhibitory postsynaptic potential (IPSP) on the postsynaptic neuron .

- Q : What are EPSP and IPSP ?
- A : They are local responses

- Q : What is their bioelectric nature ?
- A : Graded Potentials (i.e., proportional to the strength of the stimulus).

- Q: In what way do they affect the excitability of the postsynaptic membrane ?
- A: EPSP makes the postsynaptic membrane more excitable

(thus more liable to fire AP ; & IPSP makes it less excitable)

Q: In what ways do they differ from action potentials ?

- (1) They are proportional to the strength of the stimulus (i.e., do not obey All-or-None Law)
- (2) They can summate (add up)

✓ Q : Give examples of excitatory transmitters ?

- (1) Acetylcholine : Opens sodium channels in the Postsynaptic Cell Membrane → depolarization → EPSP .

- (2) Glutamate : Produces EPSP by opening of calcium channels .

- (3) Serotonin (5-Hydroxytryptamine) Present in high concentration in brain Raphe Nuclei . It is involved in sleep induction .

✓ Q : What is long-term-potentiation (LTP) ?, what transmitter is involved in it ? What is the physiological function of LTP ?

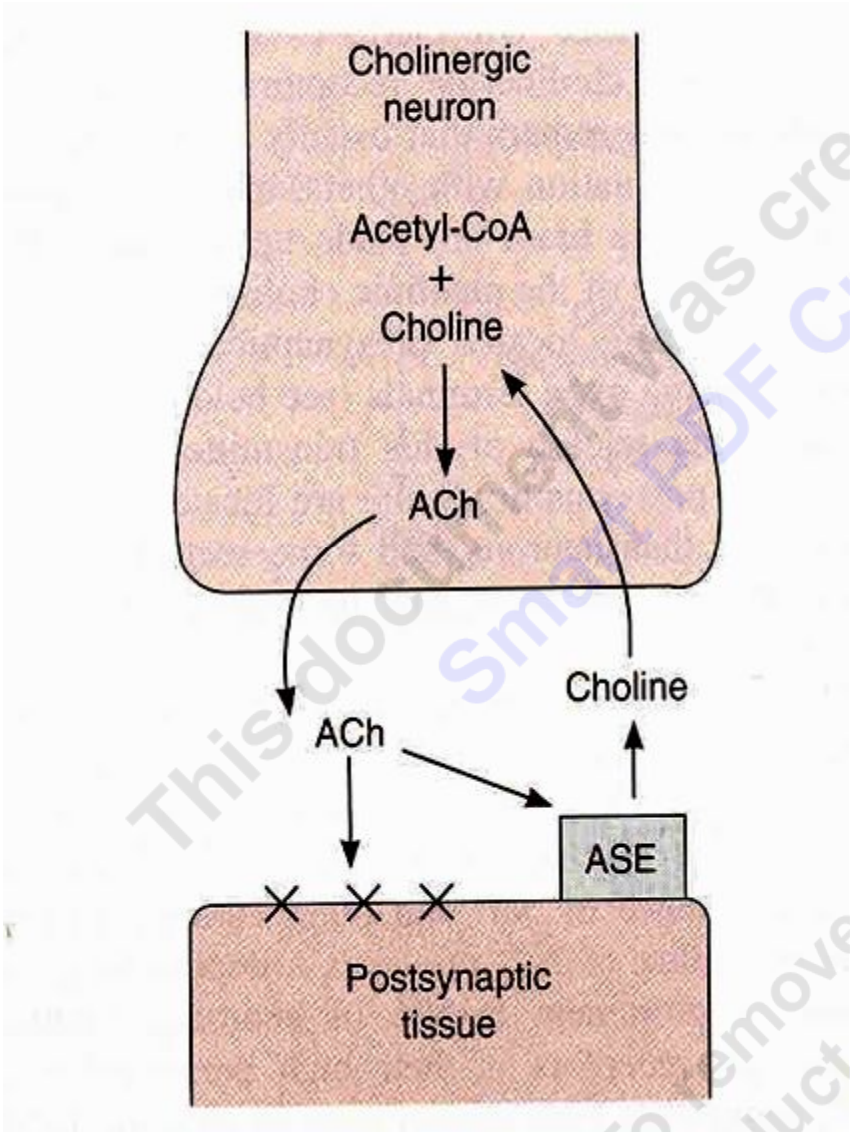
Formation of a Transmitter

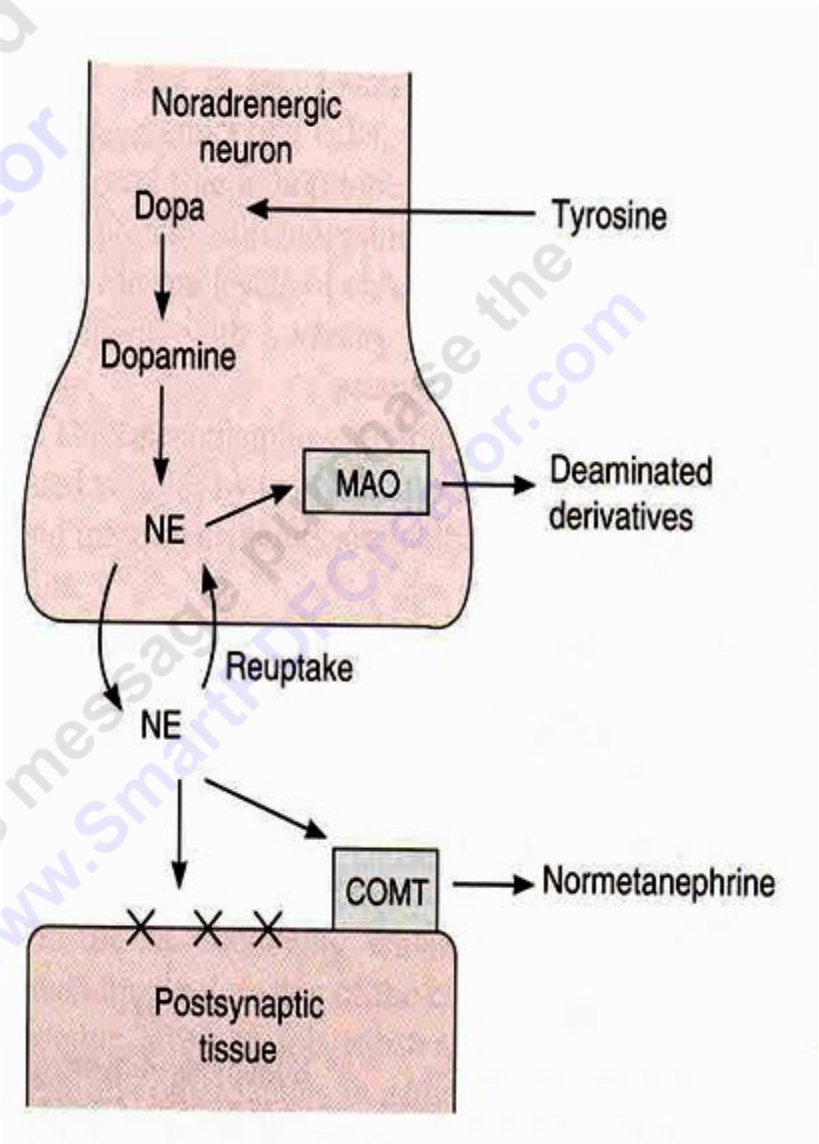
- Q : In what location of the neuron is the neurotransmitter synthesized ?
- Q : In what location of the neuron is the transmitter vesicle synthesized ?
- How are these processes functionally coupled to produce successful synaptic transmission ?

Final Fate of Transmitter

- Q : What happens to the transmitter after it has combined with its postsynaptic receptors and produced it physiological effect ?
- In the synaptic cleft there are enzymes that will then destroy the receptor .
- Examples :
- In case of Acetylcholine →

  Acetylcholinesterase (Ach-esterase) ;
- In case of Noradrenaline → Monoamine Oxidase (MAO) or Catechol-O-Methyl Transferase (COMT)





Q : Give examples of inhibitory neurotransmitters & their function ?

- (1) *GABA* : Opens which type of membrane channel ? Leading to what ? Why ? Example of physiological function ?

- (2) Enkephalin : Opens which type of membrane channel ? Leading to what ? Why ? Example of physiological function ?

Examples of Factors that Affect Neurotransmission

- What is the effect of :
- Alkalosis ?
- Hypoxia ?
- Acidosis ?

Some Properties of Synapses & Synaptic Transmission

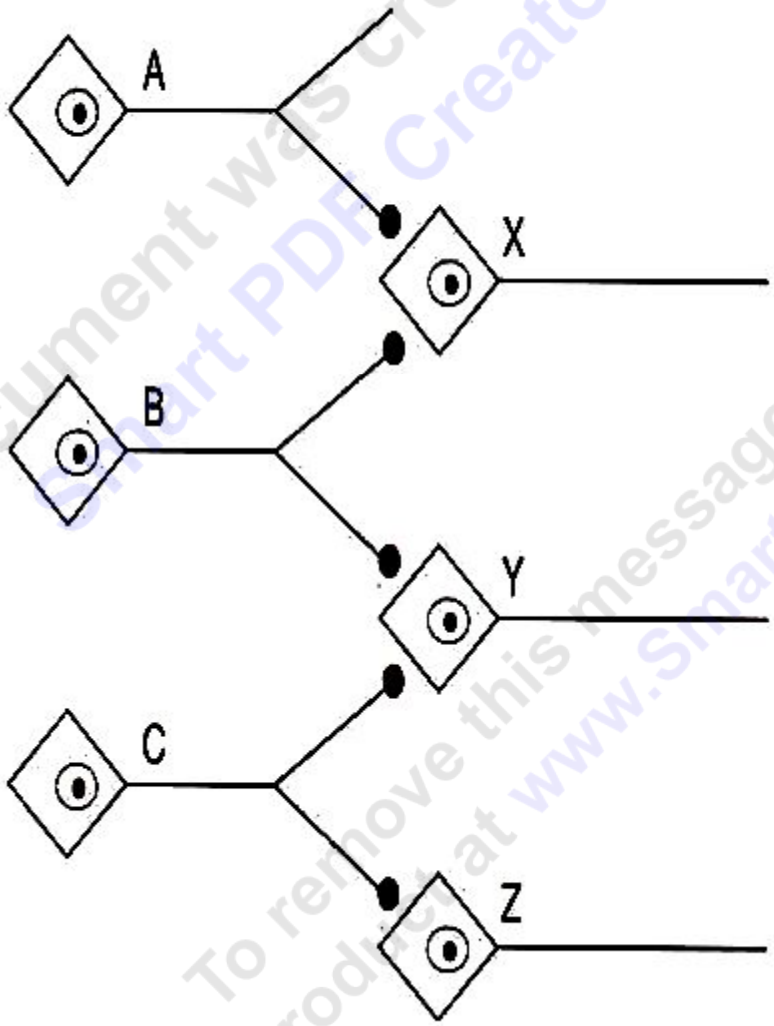
1/ ONE WAY CONDUCTION

Why ?

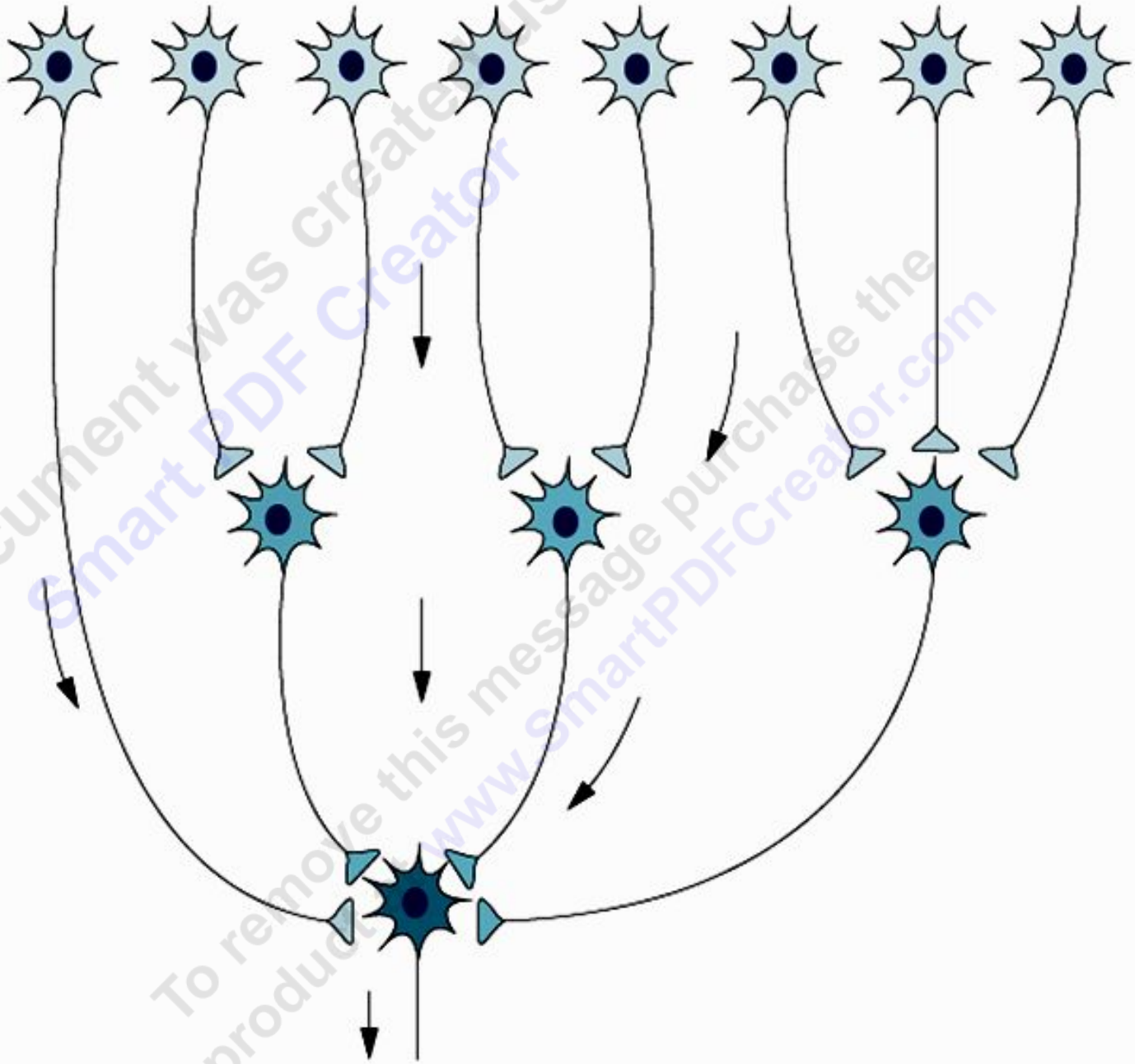
2/ SYNAPTIC DELAY

Why ?
Duration in a one synapse ?
What do we mean by total (overall) synaptic delay ?
How can we determine the number of synapses between two neurons ?

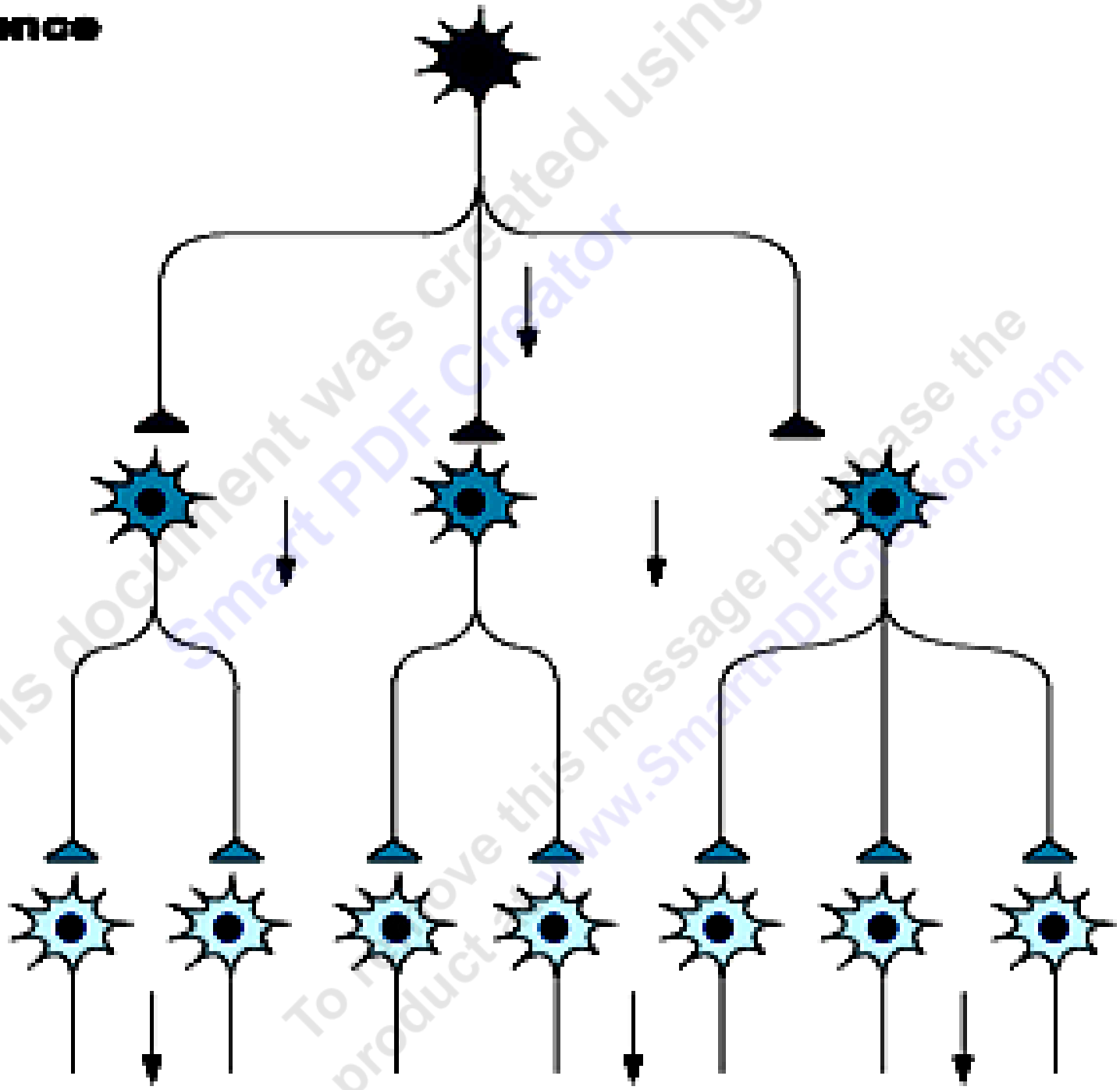
3/ Convergence & Divergence



Convergence

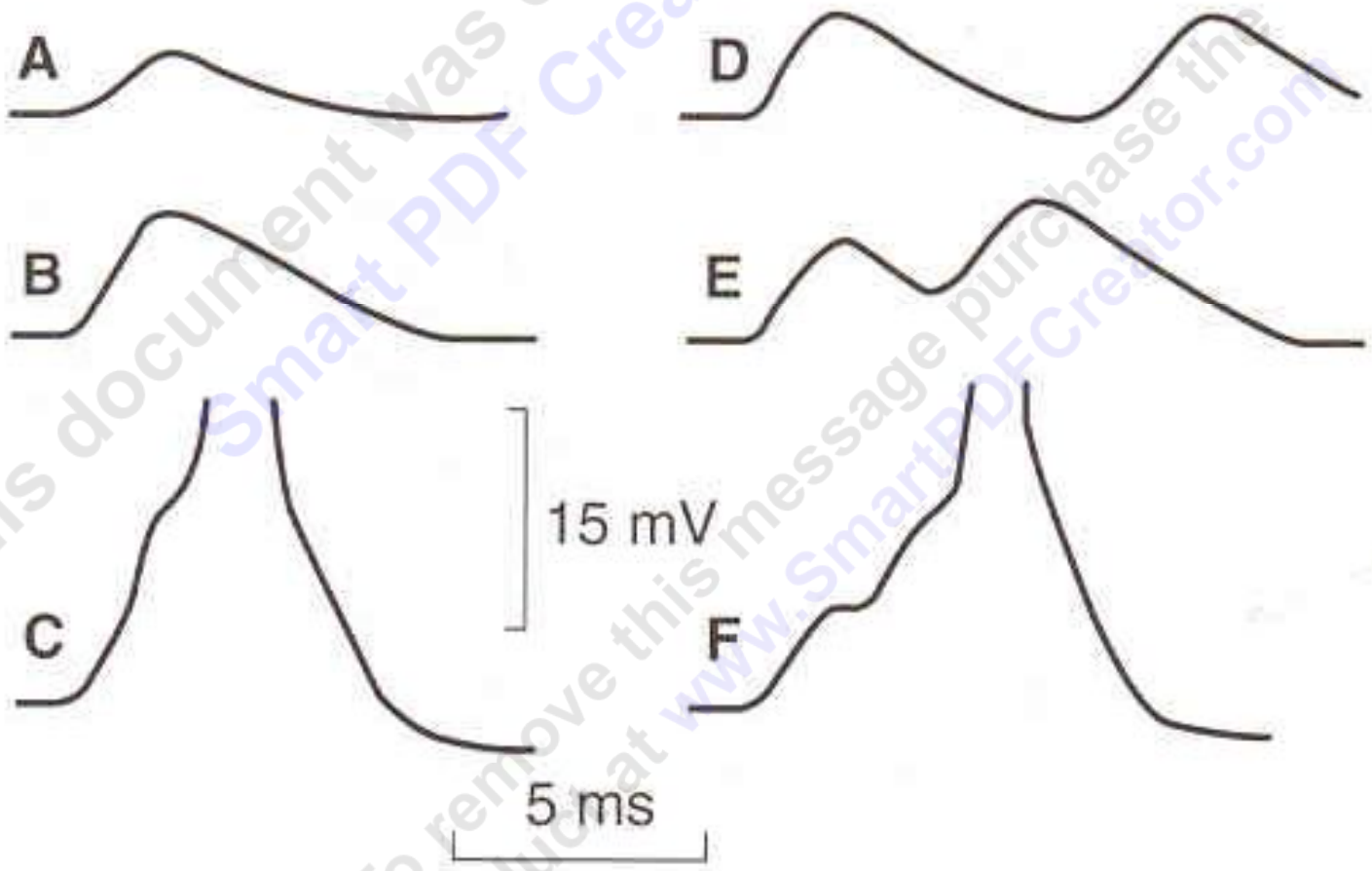


Divergence

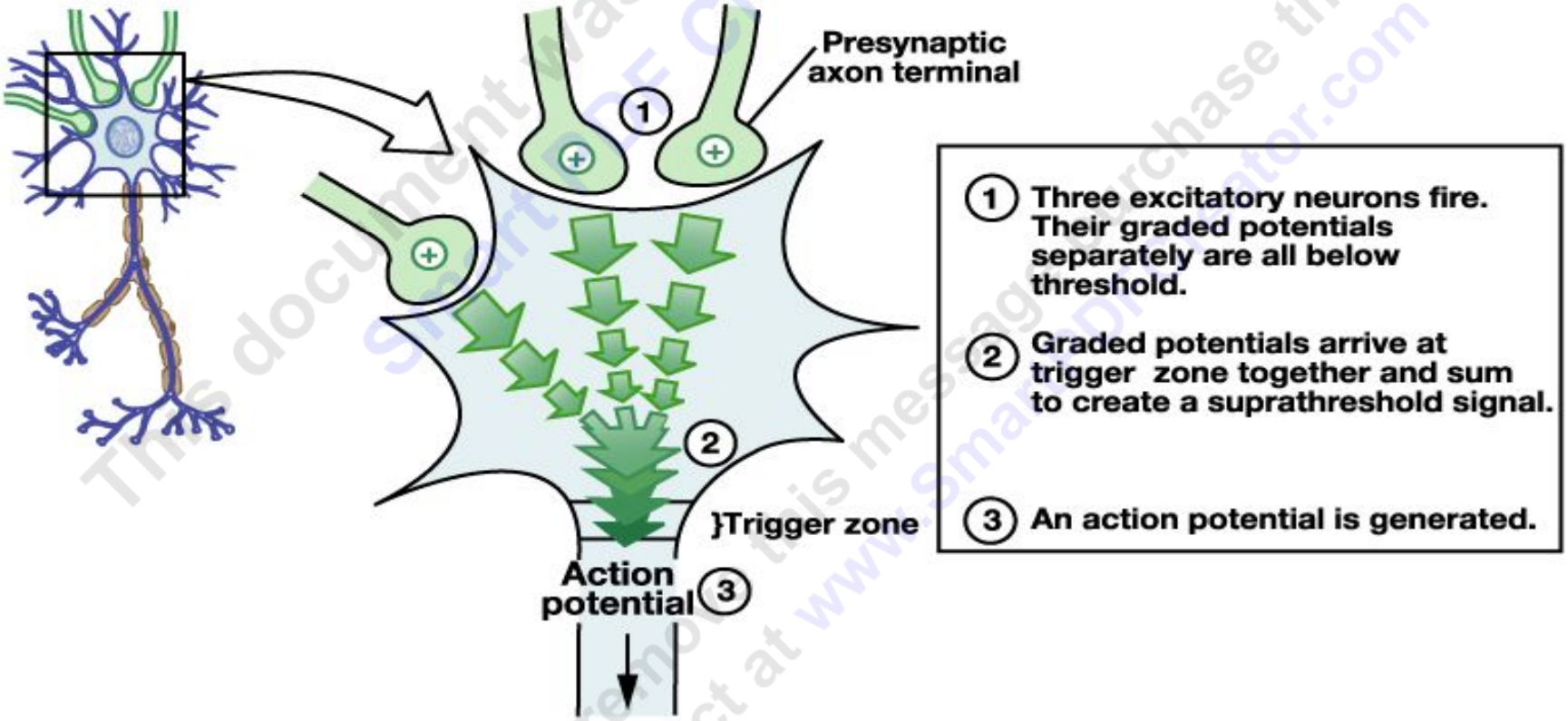


- Physiological role of convergence ?
- Physiological role of divergence ?

4/ Summation → Spatial & Temporal Summation



Spatial Summation



Spatial & Temporal Summation

- What is :
- Discharge zone ?
- Subliminal Fringe ?
- Occlusion ?

5/ Inhibition

- Explain Presynaptic inhibition ?

  Where ?

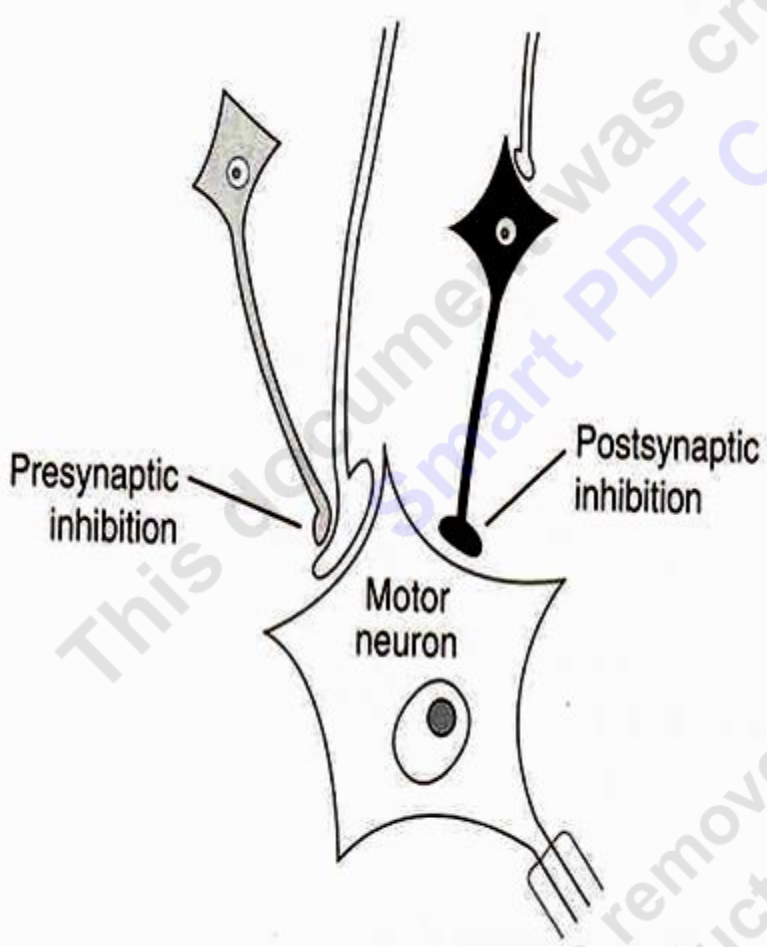
  Neurotransmitter involved ?
- Explain Postsynaptic (Direct) inhibition ?

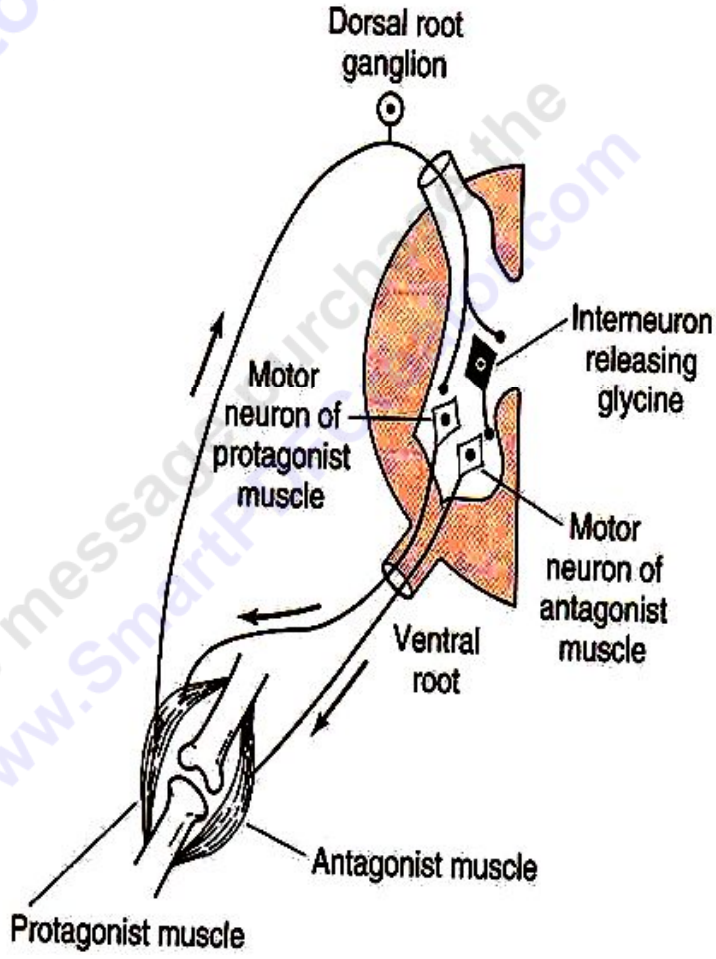
- Describe Inhibitory interneuron ?

  Example ?

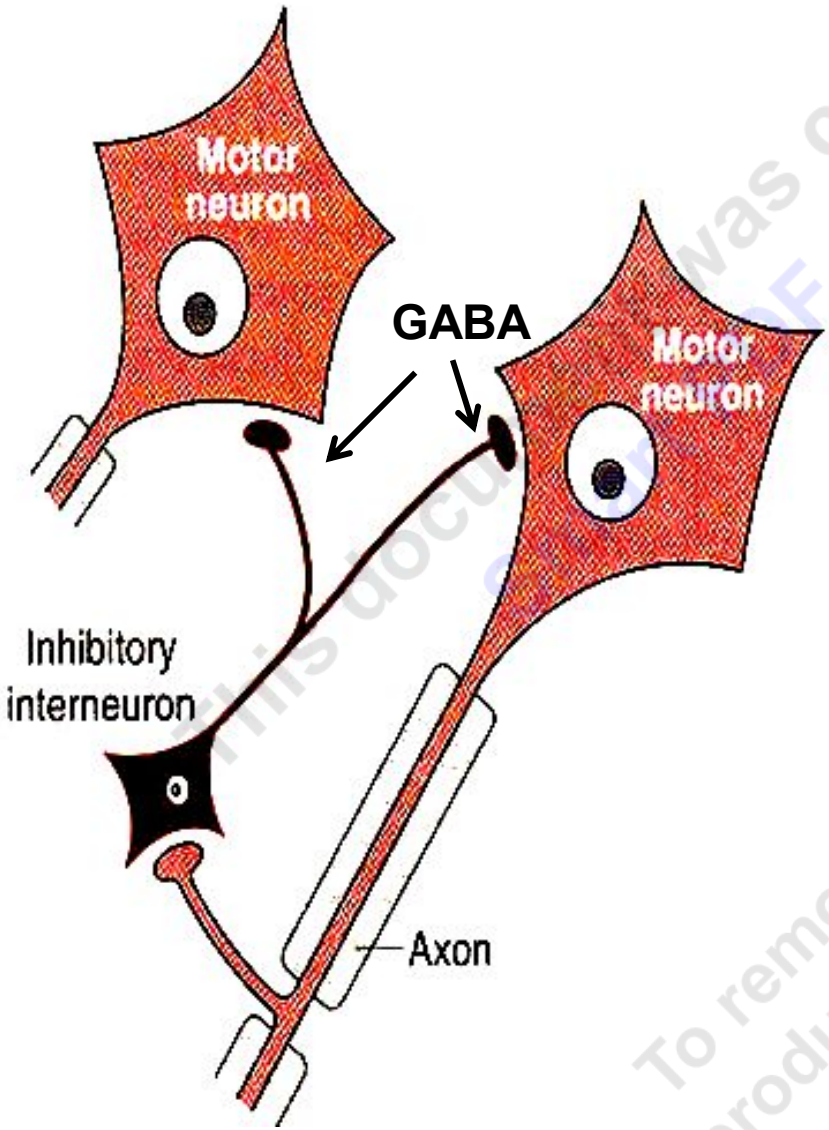
- Describe Reciprocal Inneirvation , & explain how it is nstrumental for (mediates) Reciprocal Inhibition?

Presynaptic , Postsynaptic (Direct) & Reciprocal Inhibition





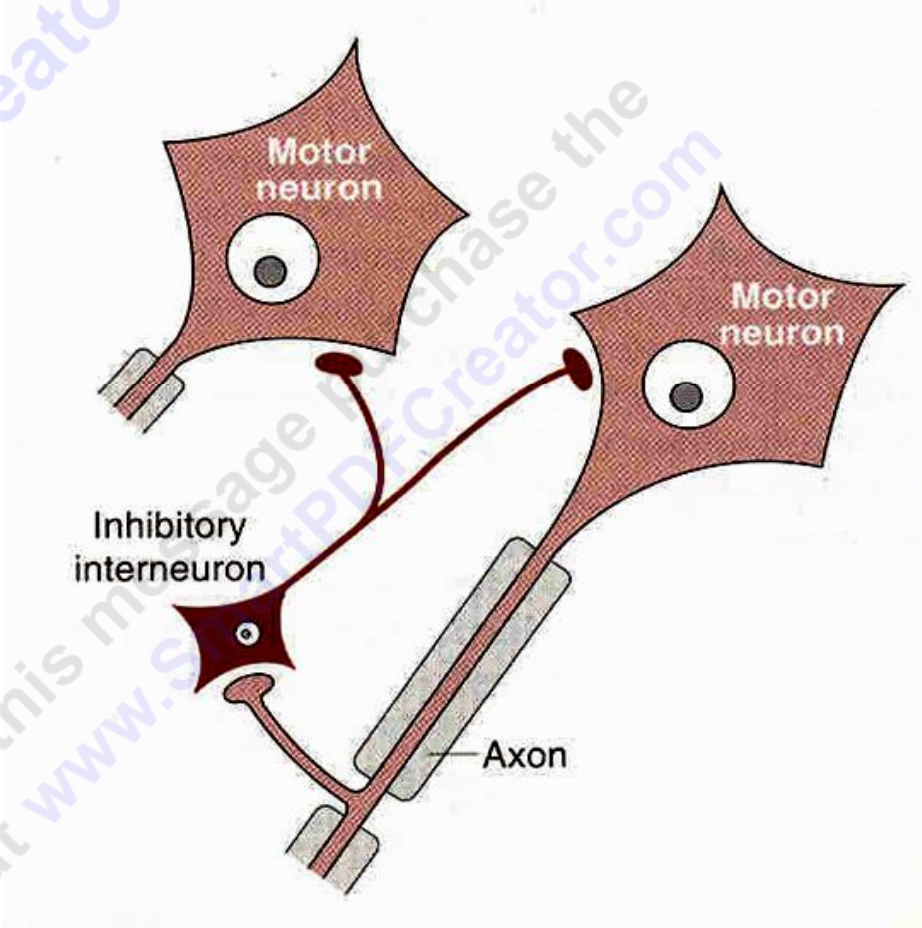
Feedback Inhibition (Renshaw Cell Inhibition)



- Neurons may also inhibit themselves in a negative feedback fashion (Negative Feedback inhibition).
- A spinal motoneuron gives a collateral that synapses Renshaw cell which is inhibitory interneuron , located in the anterior horn of spinal cord .
- Then Renshaw cell , in turn , sends back axons that inhibit the spinal motoneuron .
- These axons secrete an inhibitory transmitter that produces IPSPs on cell-bodies of motoneurons and inhibit them .

The Renshaw cell

- Is located in anterior horn in close association with motor neurons.
- it is an inhibitory cell excited by collaterals from an alpha motor neuron to project back and inhibit the same motor neuron (negative feedback fashion).



Thanks !