Synaptic transmission: postsynaptic mechanism/learning memory

突触传递：突触后机制/学习记忆

Yulong Li
李毓龙
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Outlines

- 1. synaptic transmission – postsynaptic mechanism:

  a) postsynaptic potential: how it occurs?

  b) excitatory vs. inhibitory synapses

  c) inotropic vs. metabotropic receptors

1.突触传递—突触后机制

a) 突触后电位：如何产生？

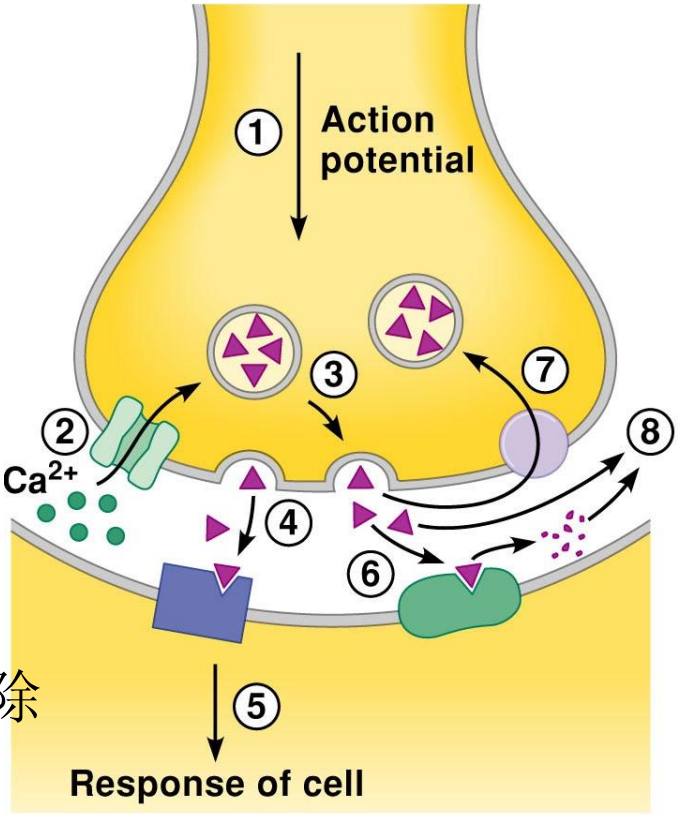
b) 兴奋 VS 抑制性突触

c) 离子型 VS 代谢型受体

Communication Across a Synapses

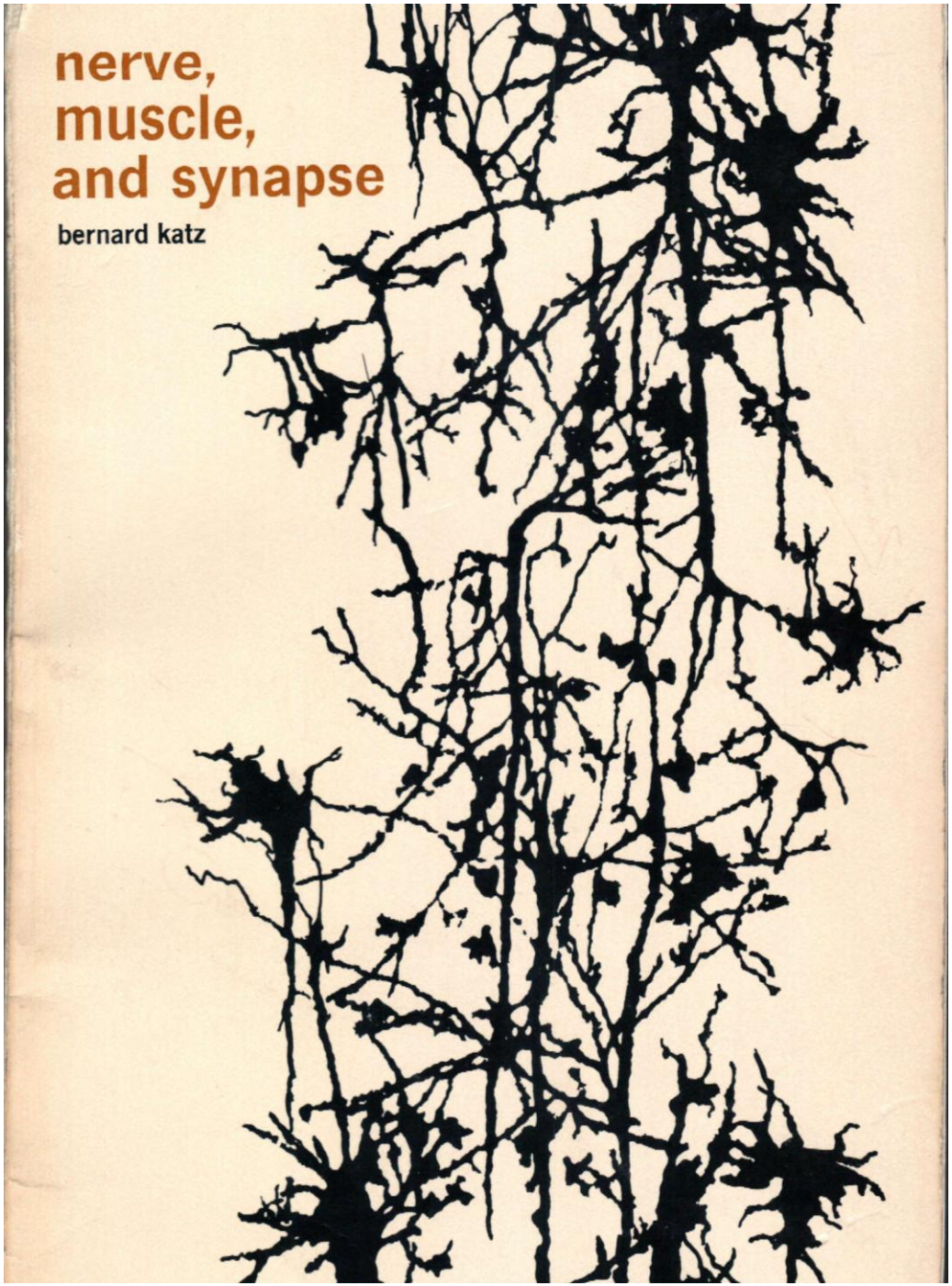
1. Action potential 动作电位
2. Voltage-gated Ca channels open
   电压门控钙离子通道打开
3. Calcium triggers exocytosis 钙离子诱导胞吐
4. NT diffuses and binds to receptor
   递质释放激活受体
5. Response in cell

   Response terminated by removing neurotransmitter from synaptic cleft 递质清除
6. Degradation降解
7. Reuptake重回收
8. Diffusion融合



(b) Active presynaptic neuron

Figure 8.2b



Katz: work on transmission of nerve impulses *Godfrey Argent*

1966

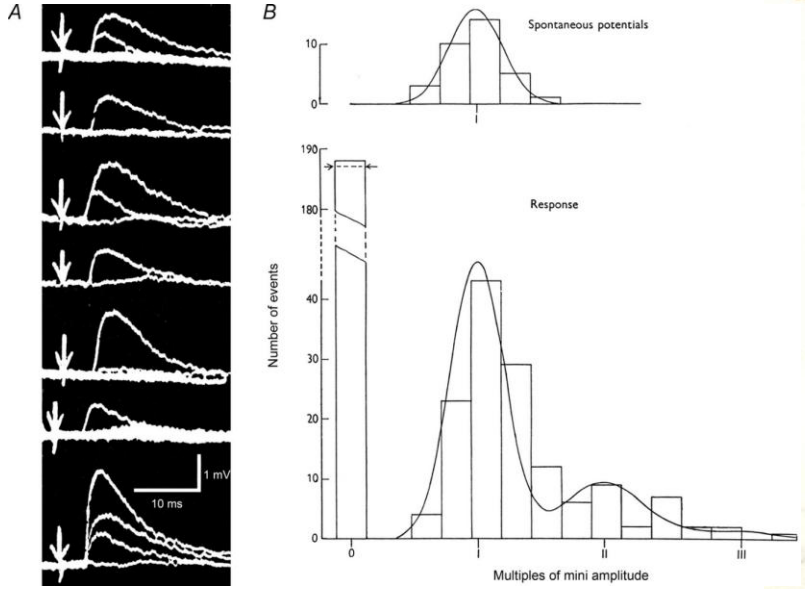
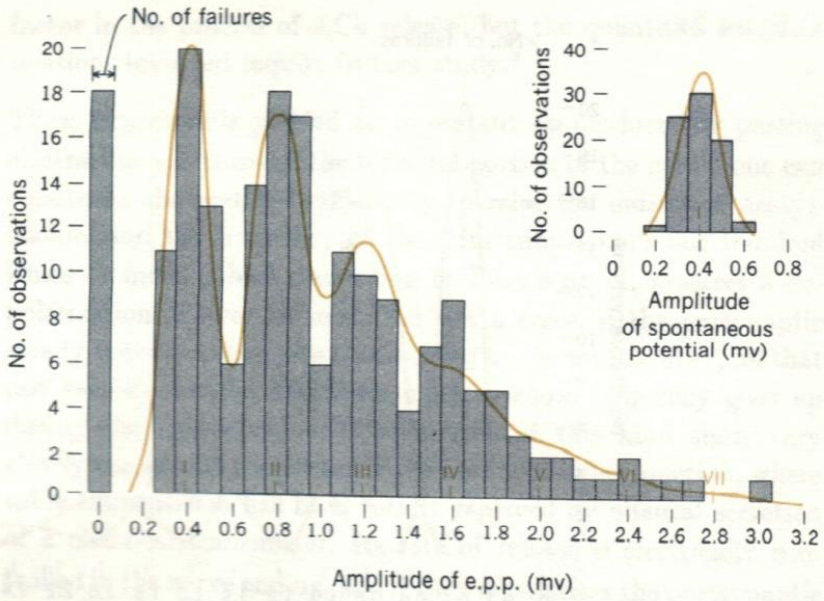
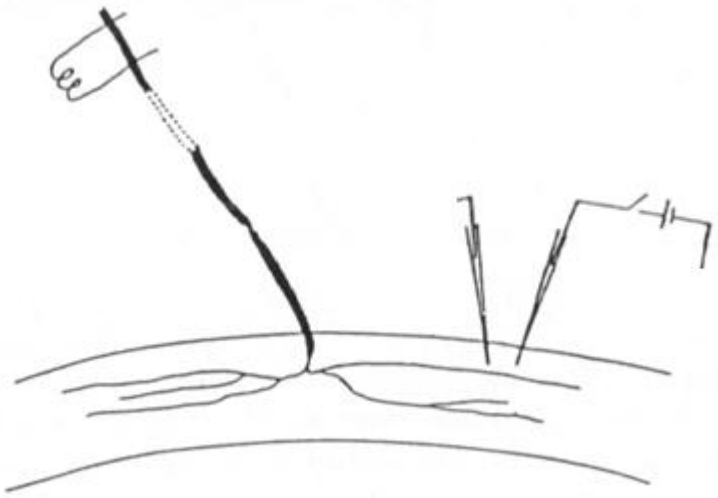


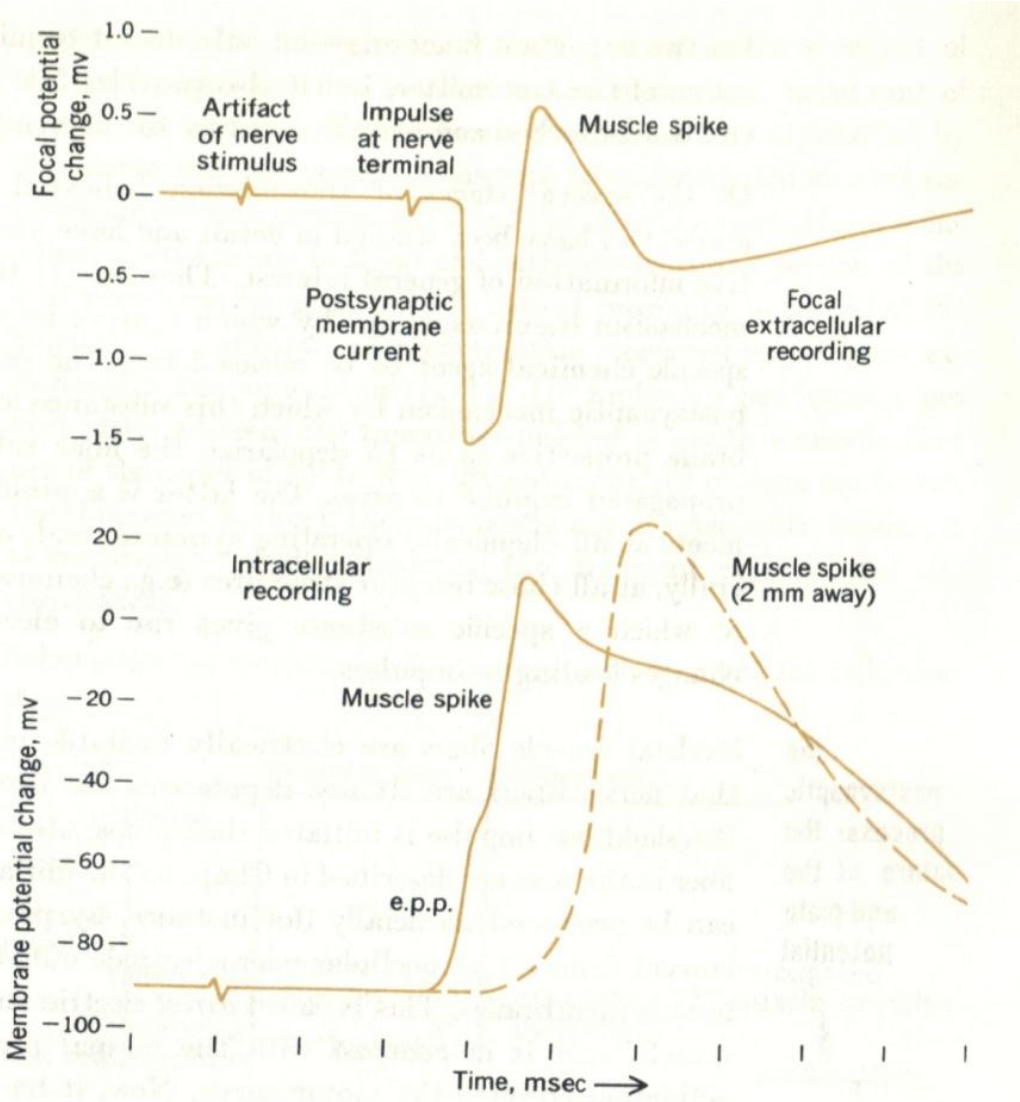
figure 30



Histograms of e.p.p. and spontaneous potential amplitudes (inset), from a mammalian end plate. Peaks of e.p.p. amplitude distribution occur at 1, 2, 3, and 4 times the mean amplitude of the spontaneous miniature potentials. A Gaussian curve has been fitted to the latter and used to calculate the theoretical distribution of e.p.p. amplitudes. Arrows indicate expected number of failures (zero amplitude). (From Boyd and Martin, 1956.)

figure 29





The initiation of a muscle impulse at the myoneural junction. Lower traces show membrane potential change at end plate (solid line) and 2 mm away (broken line). Upper trace (note different voltage scale) indicates approximate time course of focal surface potential changes (see Fatt and Katz, 1951; Katz and Miledi, 1965*a*).

Postsynaptic Electrical Signaling

突触后电信号

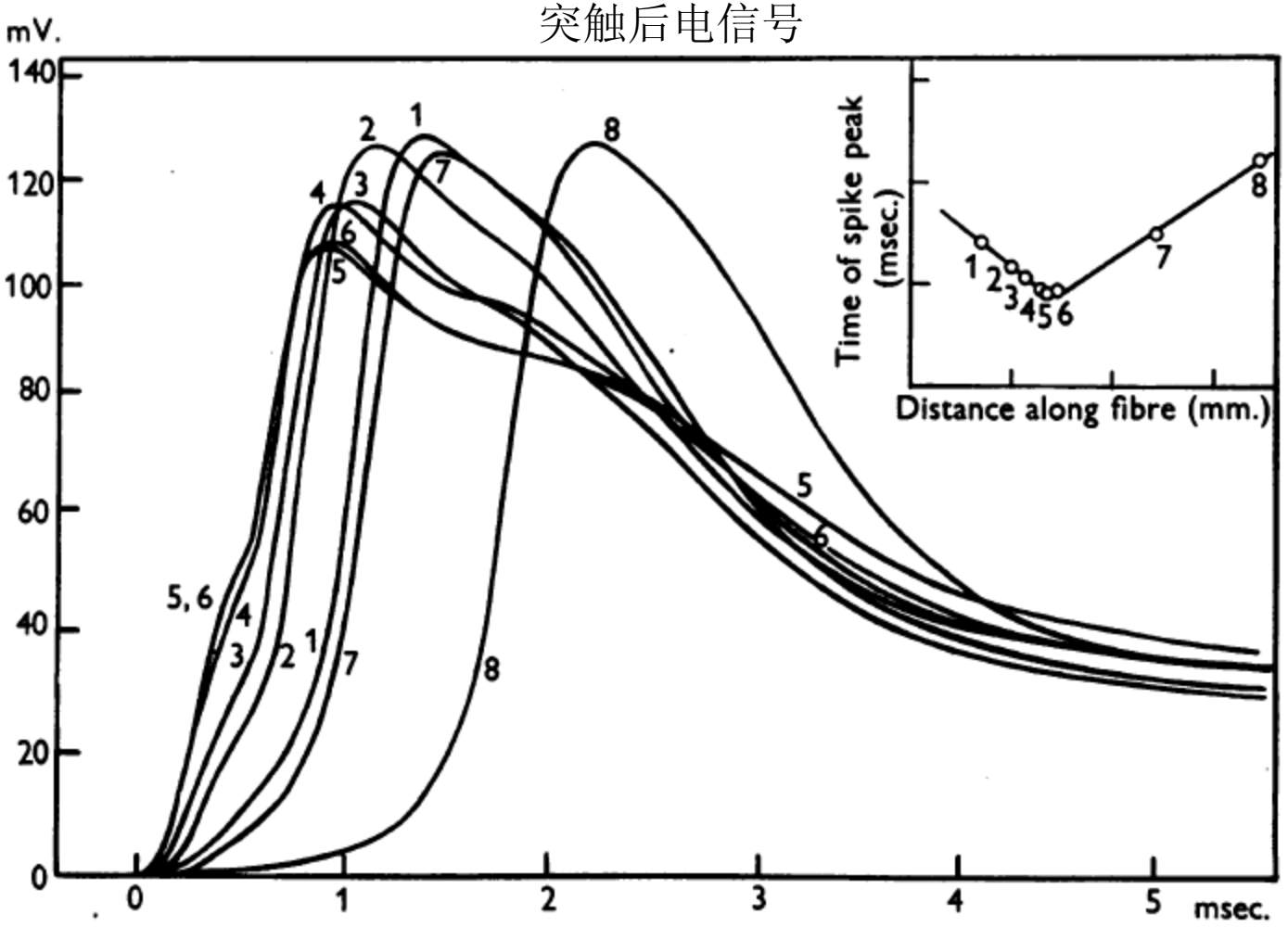
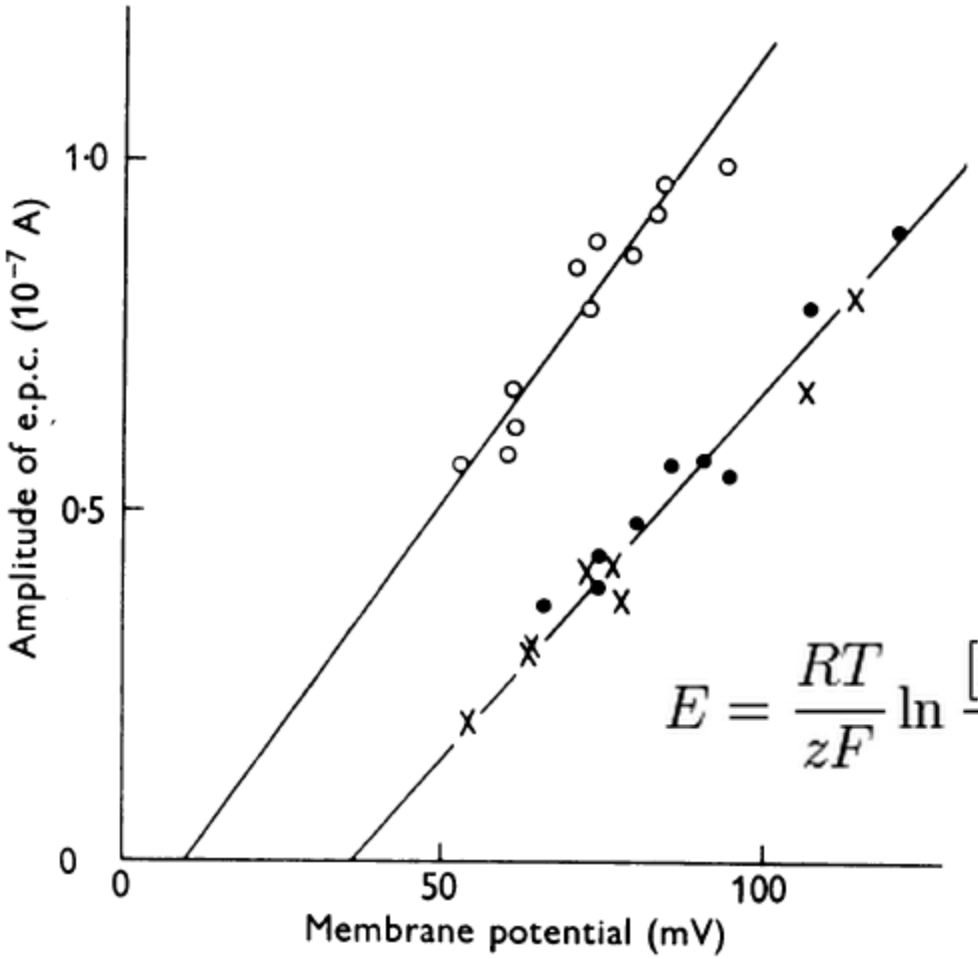


Fig. 21. The transition of electric activity from end-plate to muscle fibre.

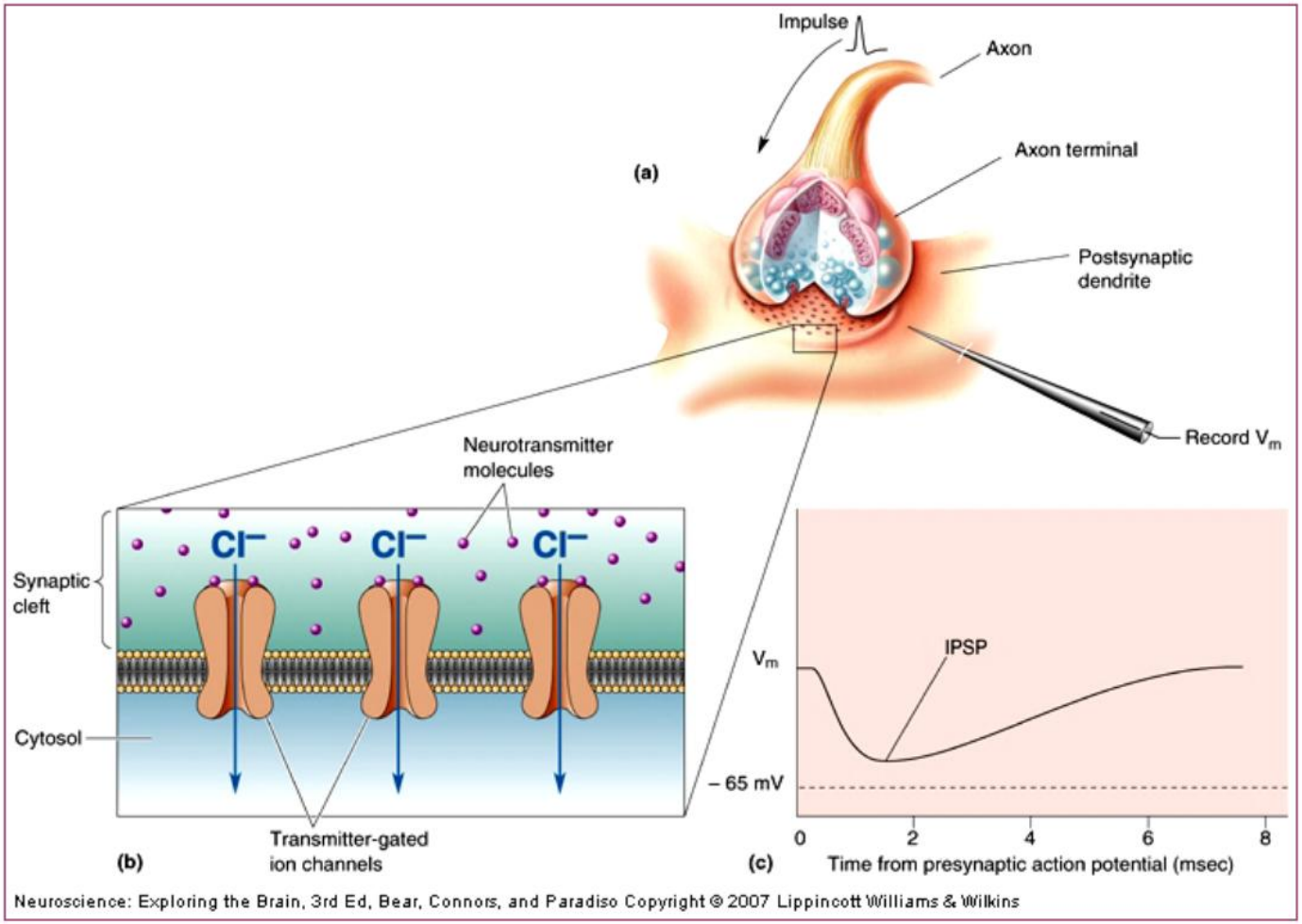
An analysis of the end-plate potential recorded with an intra-cellular electrode .Physiol. 1951 November 28;



$$E = \frac{RT}{zF} \ln \frac{[\text{ion outside cell}]}{[\text{ion inside cell}]}$$

Fig. 6. Effect of potassium concentration on e.p.c.–membrane-potential relation obtained at end-plate. Filled circles obtained in 0·5 mM-K^+ Ringer's solution. Open circles obtained after soaking in 4·5 mM-K^+ solution, and crosses obtained after return to 0·5 mM-K^+ solution.

On the permeability of end-plate membrane during the action of transmitter. J. Physiol. (Lond.) (1960)

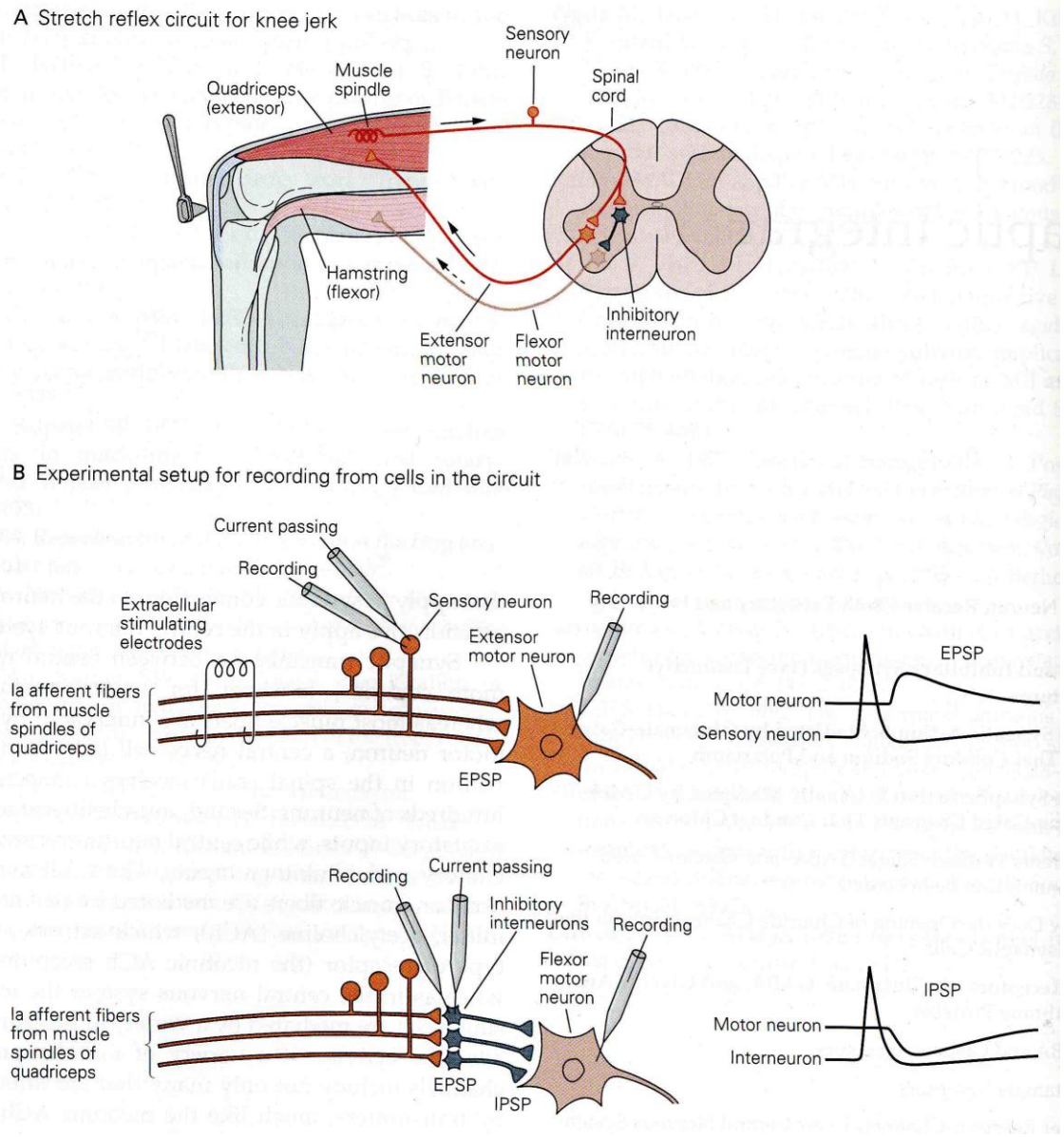


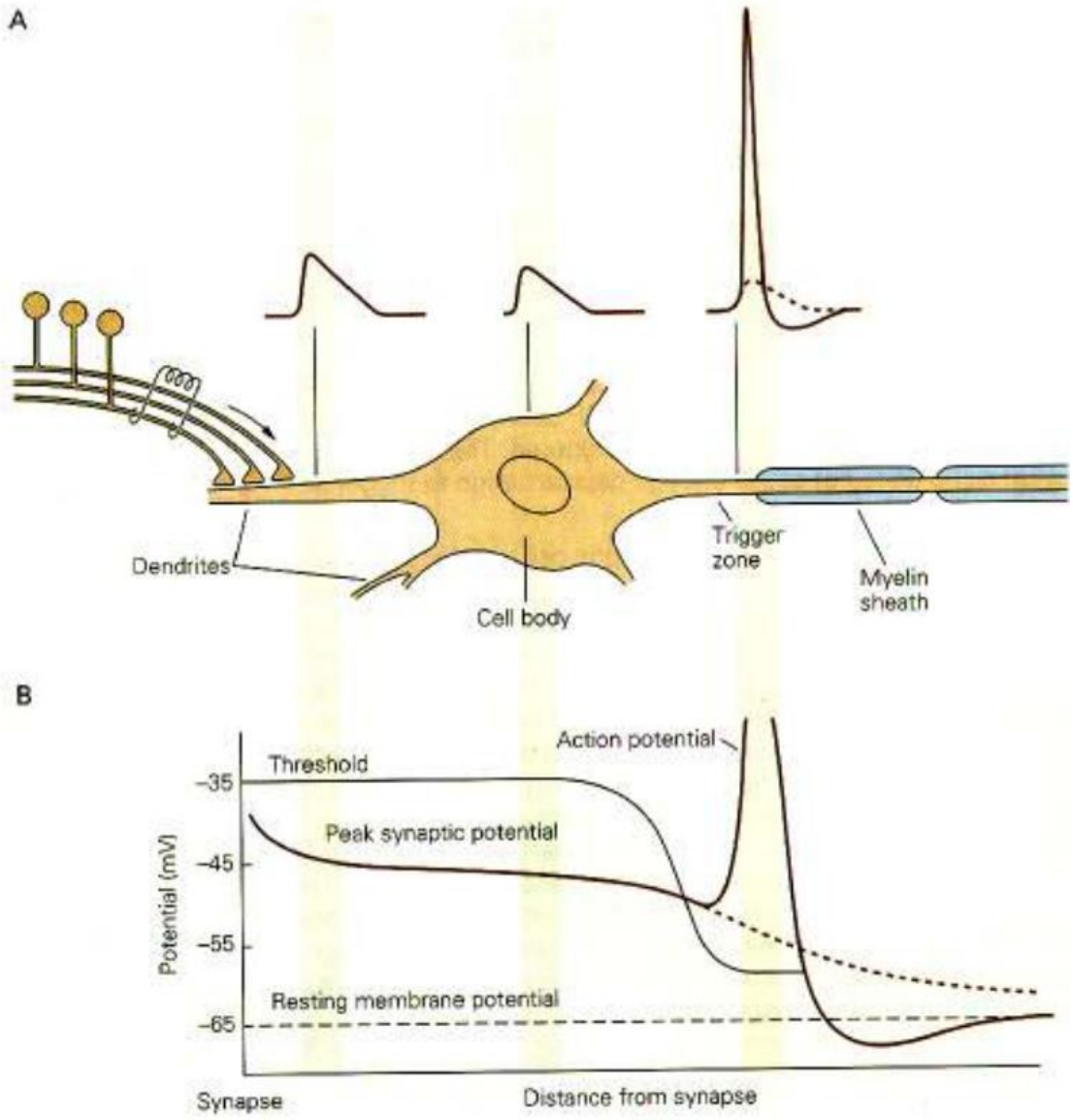
- **Hyperpolarization (IPSP)**: opening gates to allow Cl- ions entry

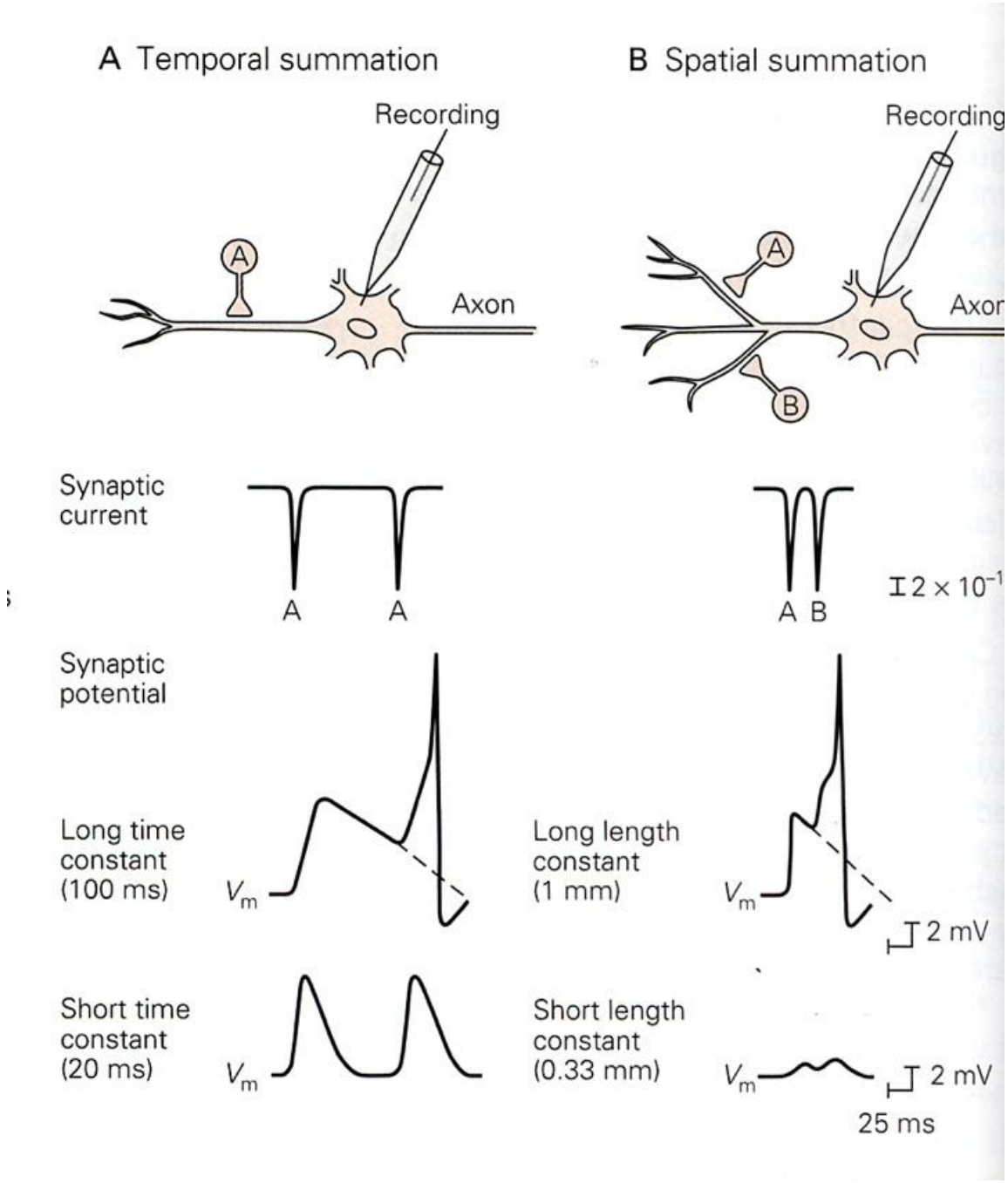
超极化（抑制性突触后电位）：氯离子跨膜流入

THE IPSP DETECTED IN MOTOR NEURON BY INPUT FROM INTERNEURON

通过中间神经元的输入检测运动神经元抑制性突触后电位

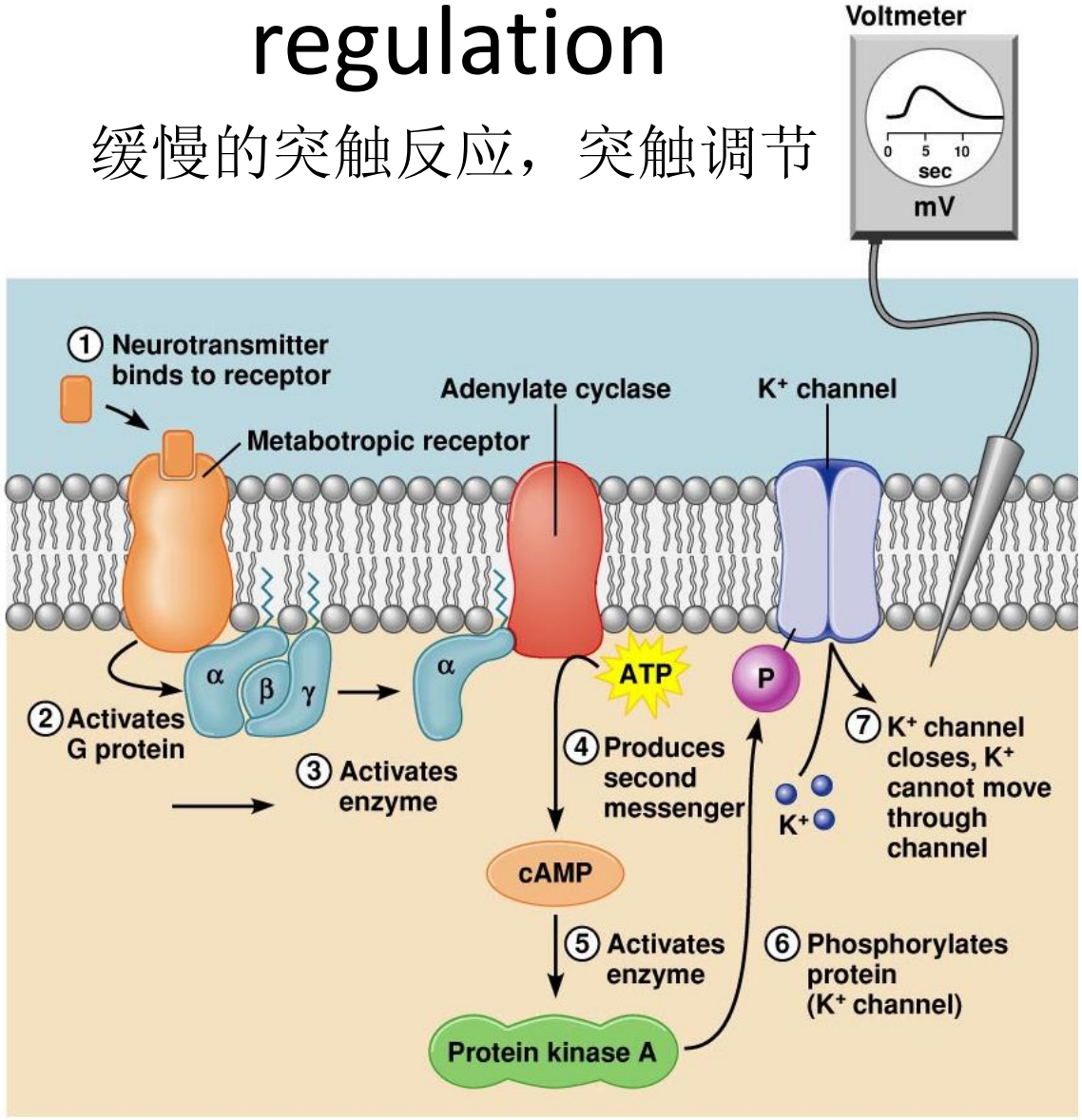



A
Dendrites
Cell body
Trigger zone
Myelin sheath
B
Threshold
Action potential
Peak synaptic potential
Resting membrane potential
Potential (mV)
-35
-45
-55
-65
Synapse
Distance from synapse

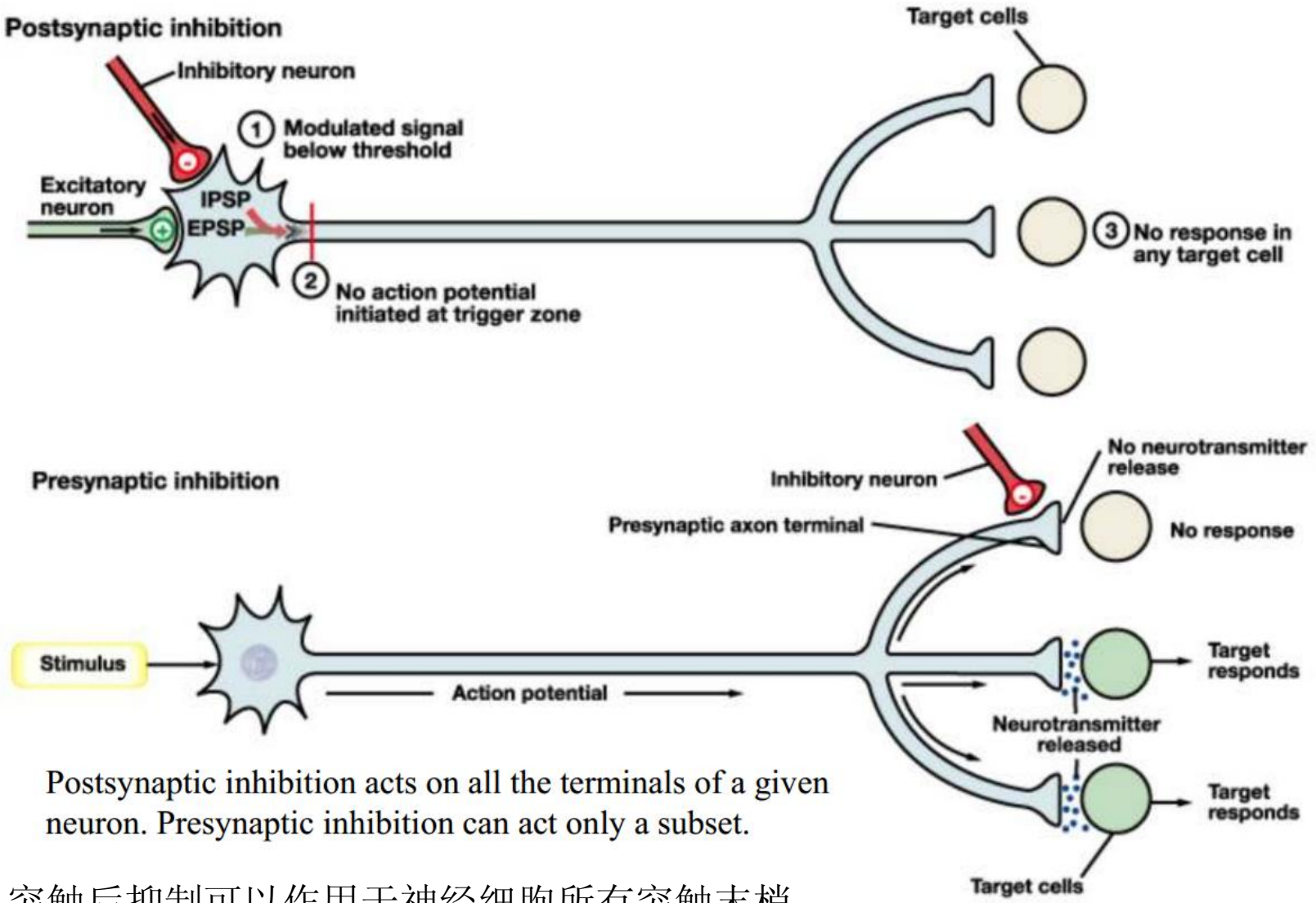

A Temporal summation
B Spatial summation
Recording
Recording
A
Axon
A
B
Axon
Synaptic current
A A
A B
I 2 × 10⁻¹
Synaptic potential
Long time constant (100 ms)
Vm
Long length constant (1 mm)
Vm
2 mV
Short time constant (20 ms)
Vm
Short length constant (0.33 mm)
Vm
2 mV
25 ms

Slow synaptic response, synaptic regulation

缓慢的突触反应，突触调节



(b) Slow response



Postsynaptic inhibition acts on all the terminals of a given neuron. Presynaptic inhibition can act only a subset.

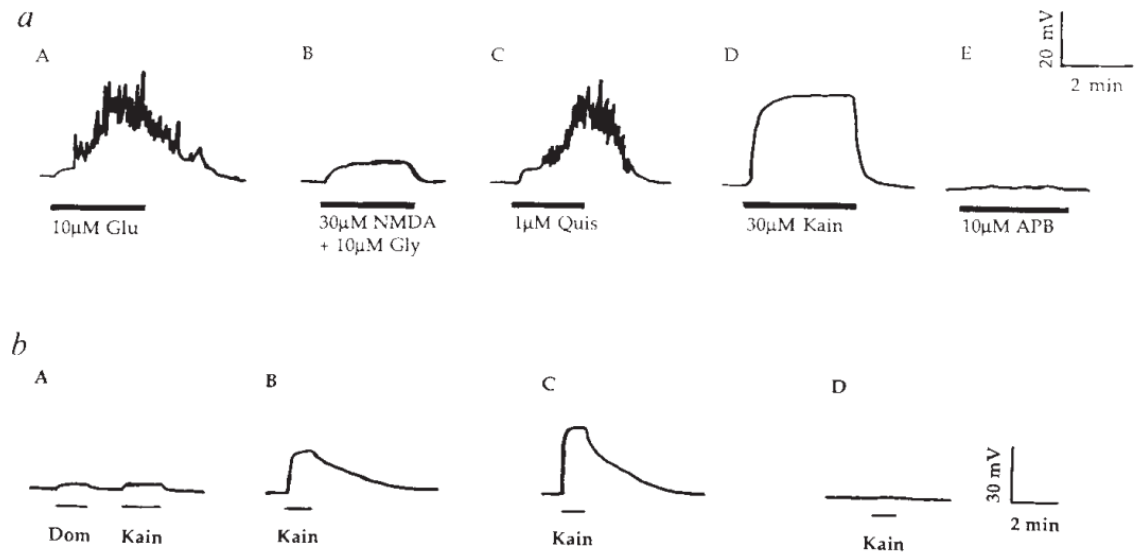
突触后抑制可以作用于神经细胞所有突触末梢。
突触前抑制只能作用在部分突触末梢。

1989 Nature

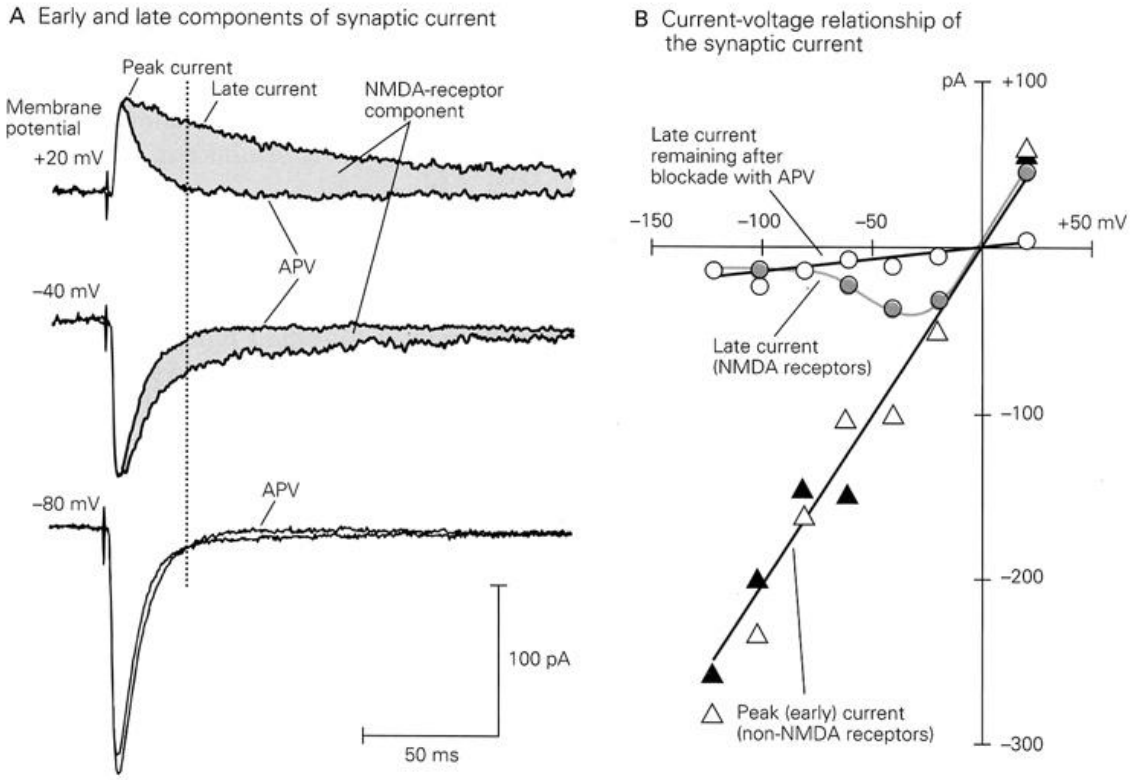
Cloning by functional expression of a member of the glutamate receptor family

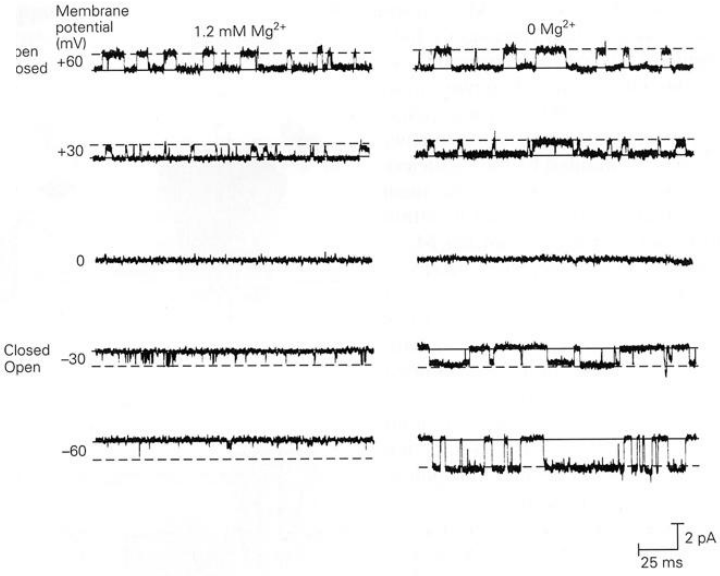
Michael Hollmann, Anne O'Shea-Greenfield, Scott W. Rogers & Stephen Heinemann

Molecular Neurobiology Laboratory, The Salk Institute for Biological Studies, La Jolla, California 92037, USA



Some receptors - e.g. the NMDA receptors are good examples of further complexity in ligand-gated channel function.

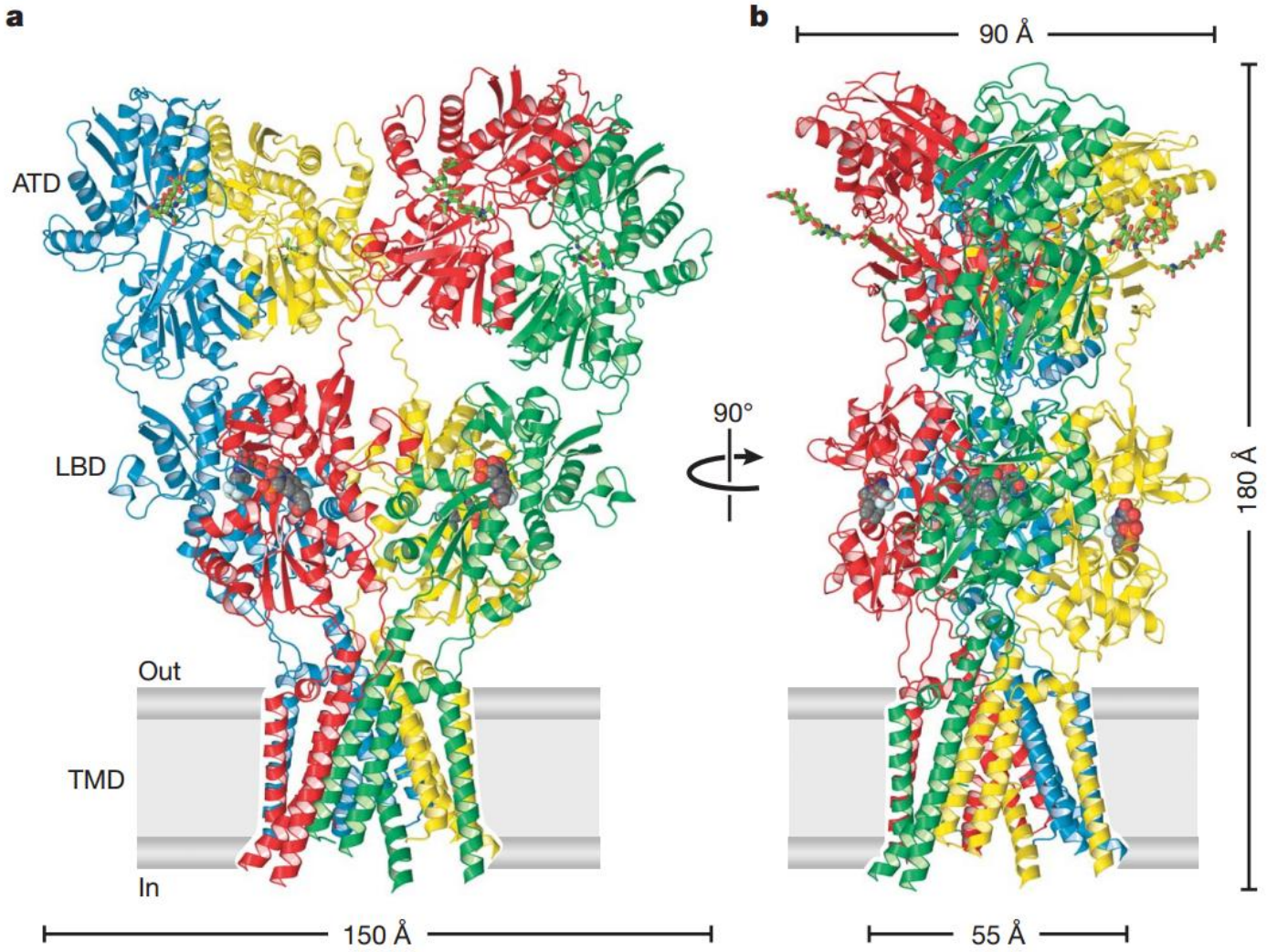




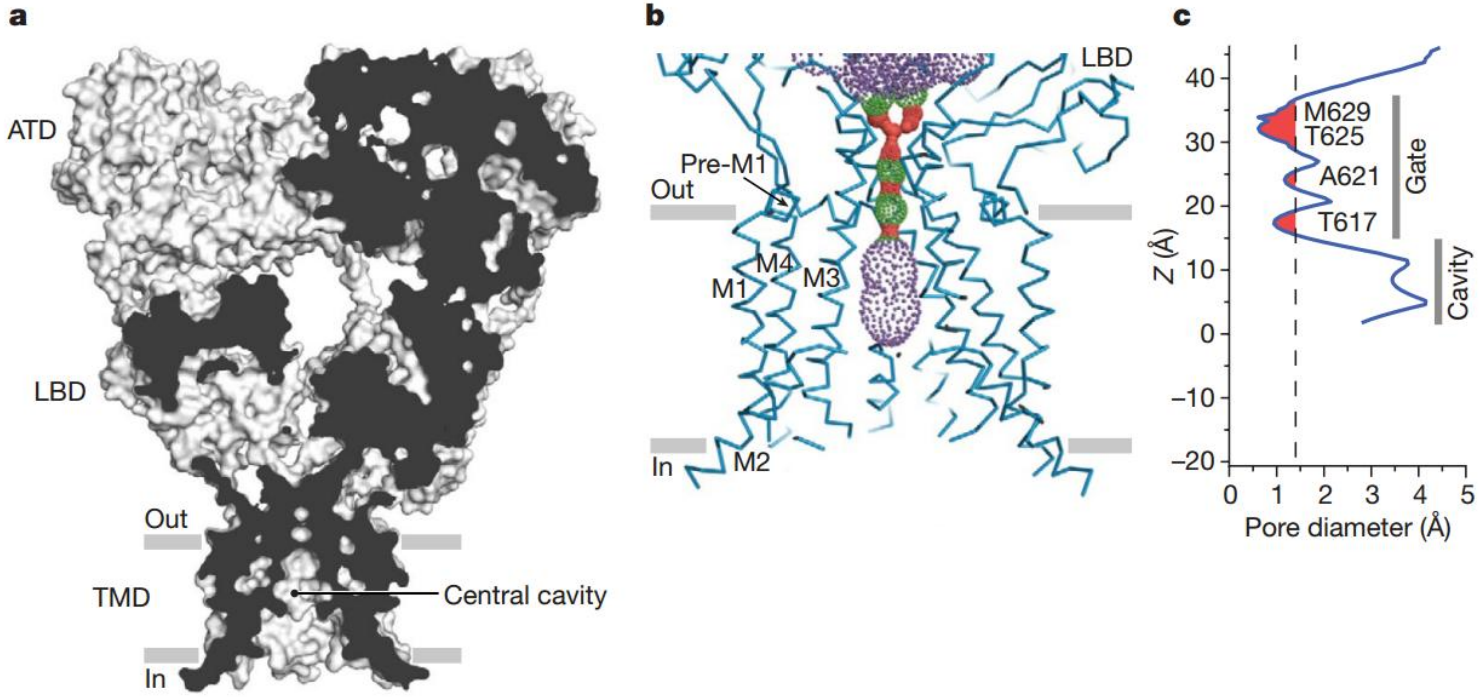
NMDA 受体是研究配体门控通道功能的例子。

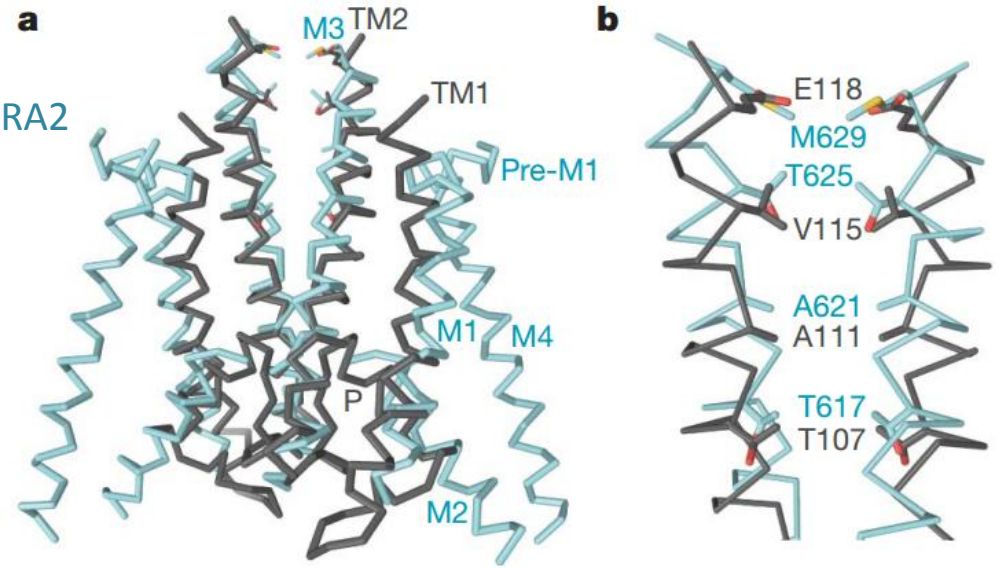
Structure of Glutmate Receptor

谷氨酸受体的结构



Sobolevsky A, AI R, Michael P, Gouaux E. Nature 2009





Light blue: GluRA2

Gray: KcsA

Sobolevsky A, AI R, Michael P, Gouaux E. Nature 2009

SELF-EVALUATION QUESTIONS:

1. What is electrical transmission and how is it different from chemical transmission?

电传递是什么？与化学传递的区别是什么？

2. What is an EPSP and how is it produced? What is an IPSP and how is it produced?

什么是兴奋性突触后电位和抑制性突触后电位？产生的机制是什么？

3. Define the term reversal potential and explain why the reversal potential for EPSPs and IPSPs are different.

什么是反向电位，EPSP和IPSP的反向电位为什么不同?

4. Outline the differences between spatial and temporal summation.

空间，时间总和的区别？

5. Why is summation of EPSPs necessary for generation of APs in most neurons?

神经细胞动作电位的产生为什么需要EPSP？

neurotree

Heinrich Otto Wieland
University of Munich(Chemistry Tree)

Feodor Lynen
University of Munich(Chemistry Tree)

Shosaku Numa
Kyoto University
(Info)

Kazuhiko Fukuda
Kyoto University

Masaharu Noda
NIBB

Hitoshi Morikawa
UT Austin
+

Keisuke Yonehara
Friedrich Miescher Institute

Takeshi Y. Hiyama
National Institute for Basic Biology

- Shosaku Numa

Yi Rao (Northwestern University, Peking University School of Life Sciences)
| (grad student for)
Lily Jan (University of California, San Francisco)
| (grad student for)
Max Delbruk (California Institute of Technology)(FlyTree)
| (post-doc for)
Thomas Hunt Morgan (California Institute of Technology)(FlyTree)