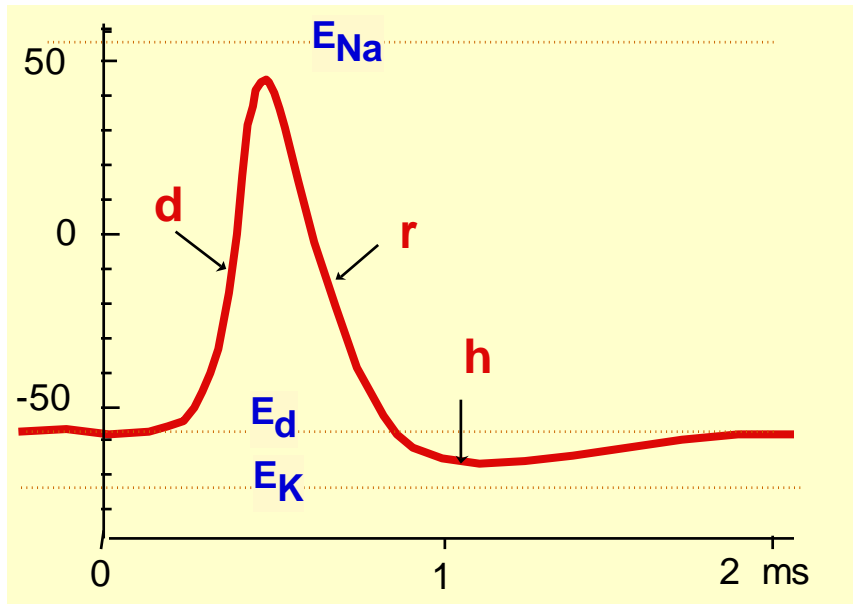


EPSP ve IPSP' nin GHK bağıntısına dayalı incelenmesi

Doç. Dr. Erkan Tuncay

Goldman-Hodgkin-Katz Denklemi

$$E_m = \frac{RT}{F} \ln \frac{P_K [K^+]^{d \cdot 1/2} + P_{Na} [Na^+]^{d \cdot 1/2} + P_{Cl} [Cl^-]^{iç}}{P_K [K^+]^{iç} + P_{Na} [Na^+]^{iç} + P_{Cl} [Cl^-]^{d \cdot 1/2}}$$



$P_K \gg P_{Na}, P_{Cl}$ için

$$E_m \approx \frac{RT}{F} \ln \frac{[K^+]^{d \cdot 1/2}}{[K^+]^{iç}} \rightarrow E_K$$

Sodyum iletkenliğinde deęişme

$$E_m = \frac{RT}{F} \ln \frac{P_K [K^+]^{d\frac{1}{2}} + P_{Na} [Na^+]^{d\frac{1}{2}} + P_{Cl} [Cl^-]^{iç}}{P_K [K^+]^{iç} + P_{Na} [Na^+]^{iç} + P_{Cl} [Cl^-]^{d\frac{1}{2}}}$$

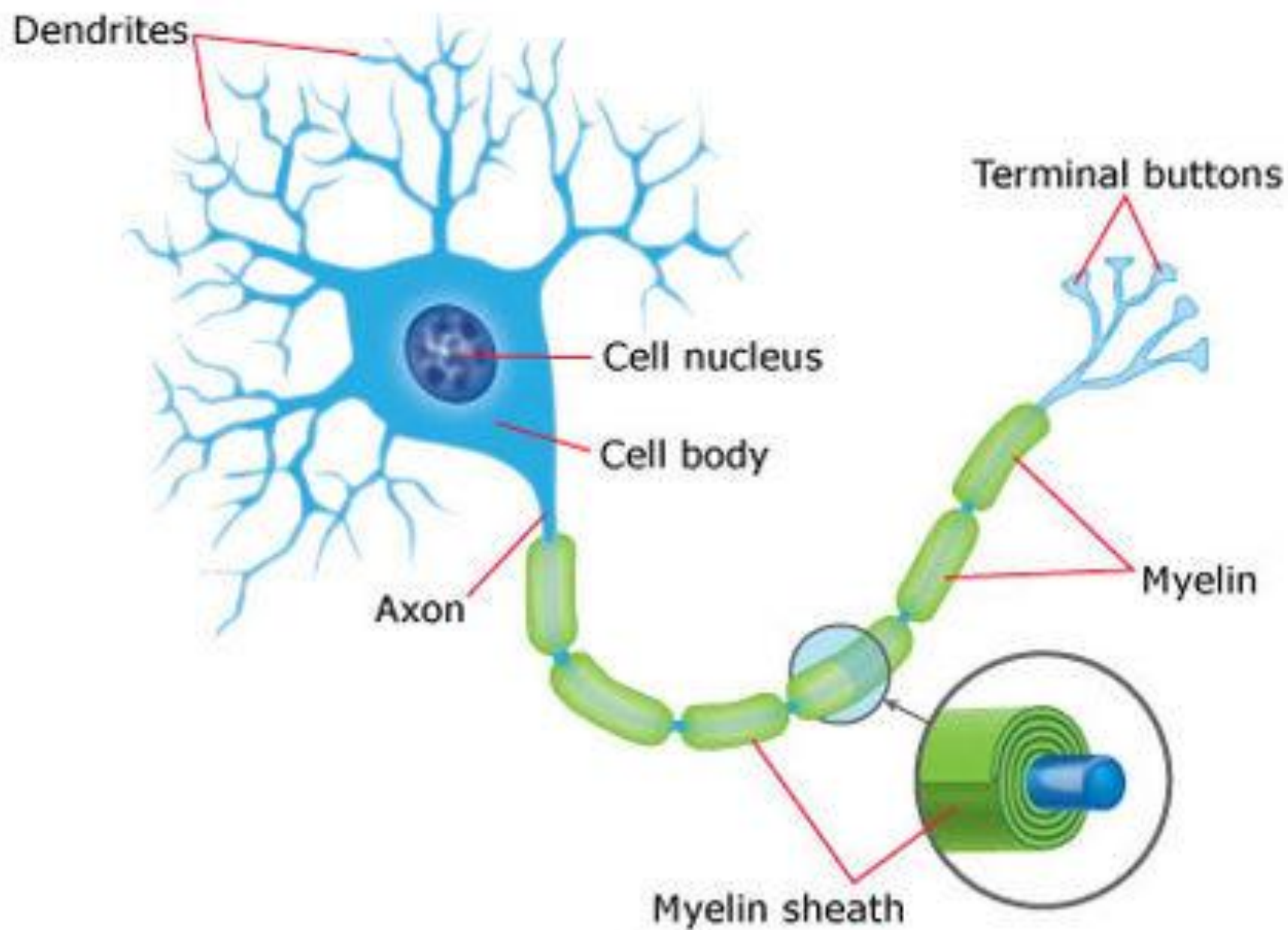
Dinlenimde $P_K / P_{Na} / P_{Cl} = 1 / 0,04 / 0,45$

Aksiyon potansiyeli sırasında $P_K / P_{Na} / P_{Cl} = 1 / 20 / 0,45$

Geçirgenliklerin bu oranları kullanıldığında, zar potansiyeli,
Dinlenimde
 $E_m \rightarrow -53$ mV,
Aksiyon potansiyeli yükselme evresinde,
 $E_m \rightarrow +42$ mV
bulunmaktadır.

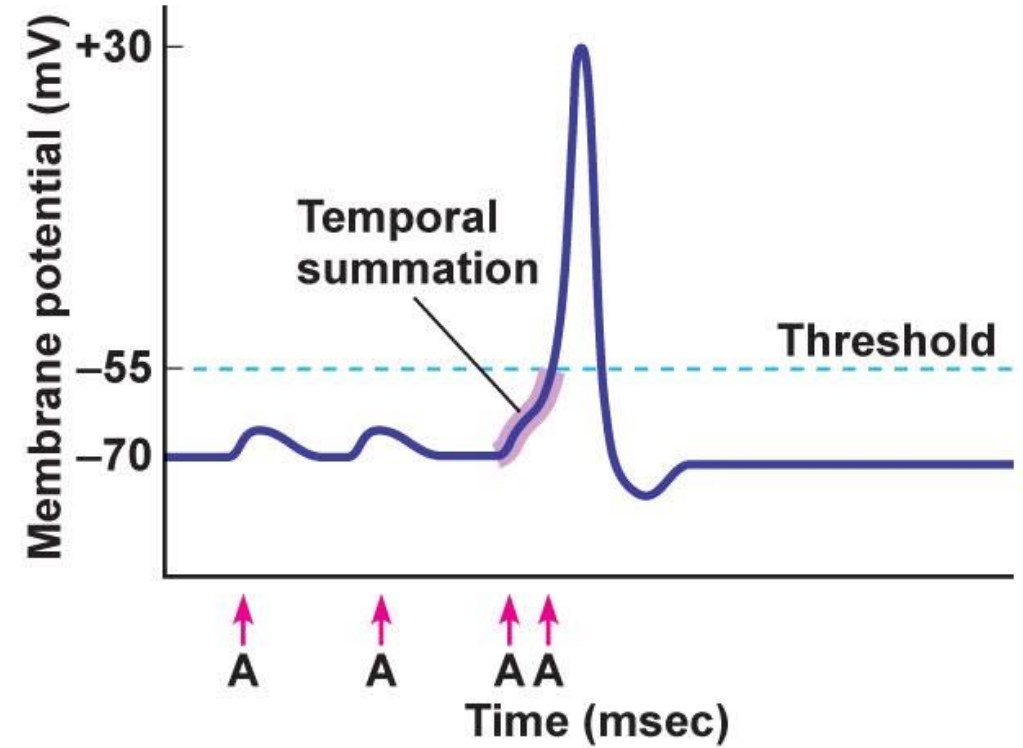
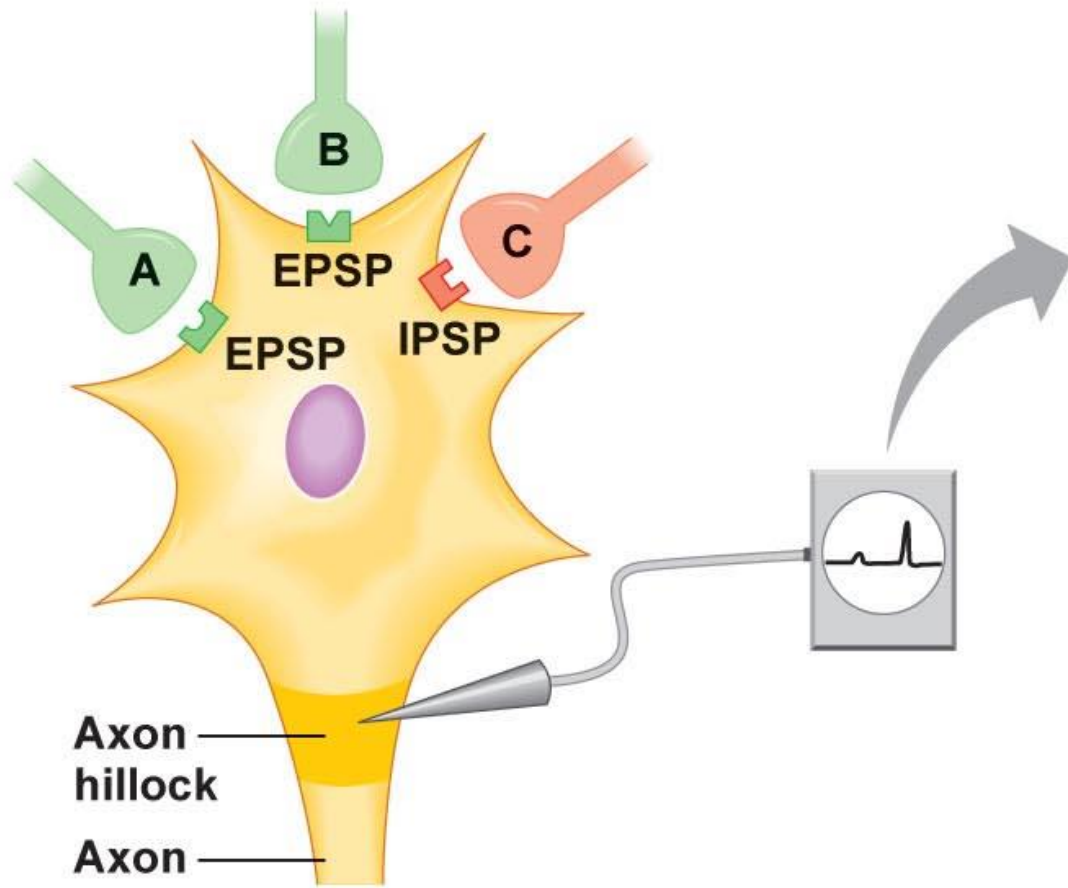
Madde	Konsantrasyon, m mol/kg su			Denge potansiyeli E_i (mV)
	Akso-plazma	Kan	Deniz suyu	
Na ⁺	50	440	460	+54
K ⁺	400	20	10	-75
Cl ⁻	40-150	560	540	
Ca ²⁺	0,4	10	10	
Mg ²⁺	10	53	54	
ATP	0,7-1,7			
Organik anyonlar	385			
Su (g/kg)	865	870	966	

Dinlenim zar potansiyeli: - 50 / - 70 mV

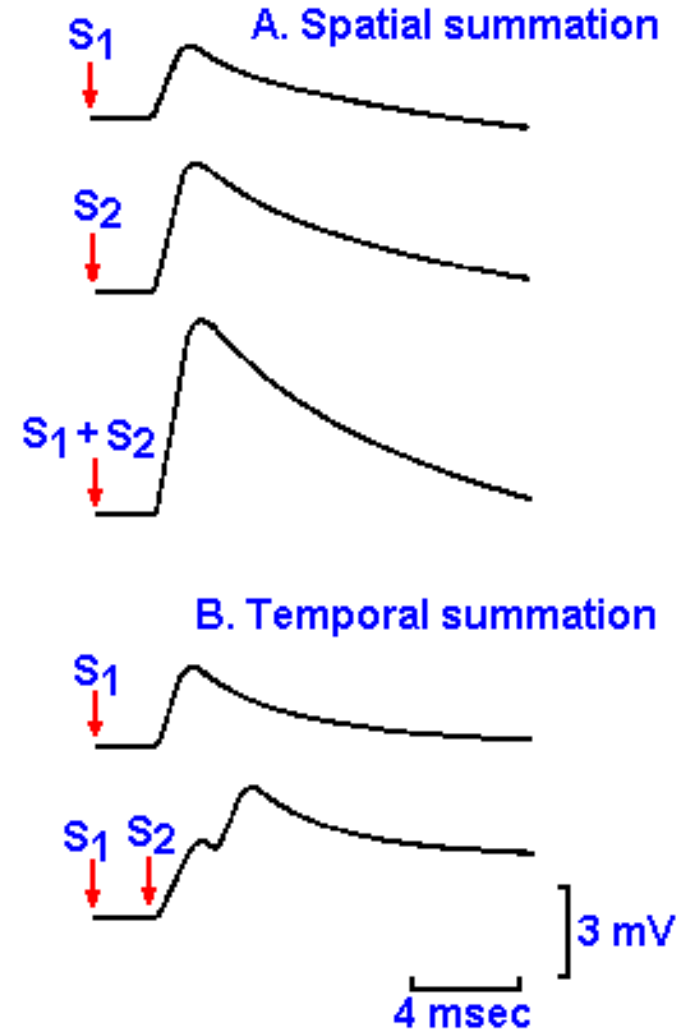
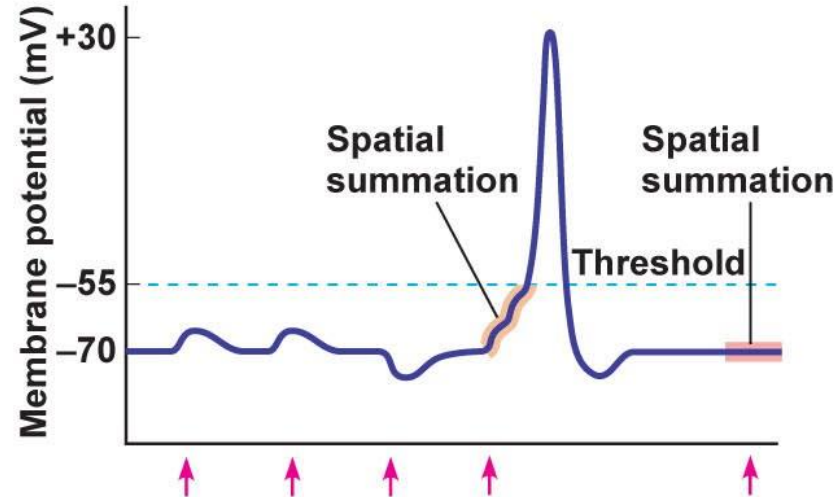
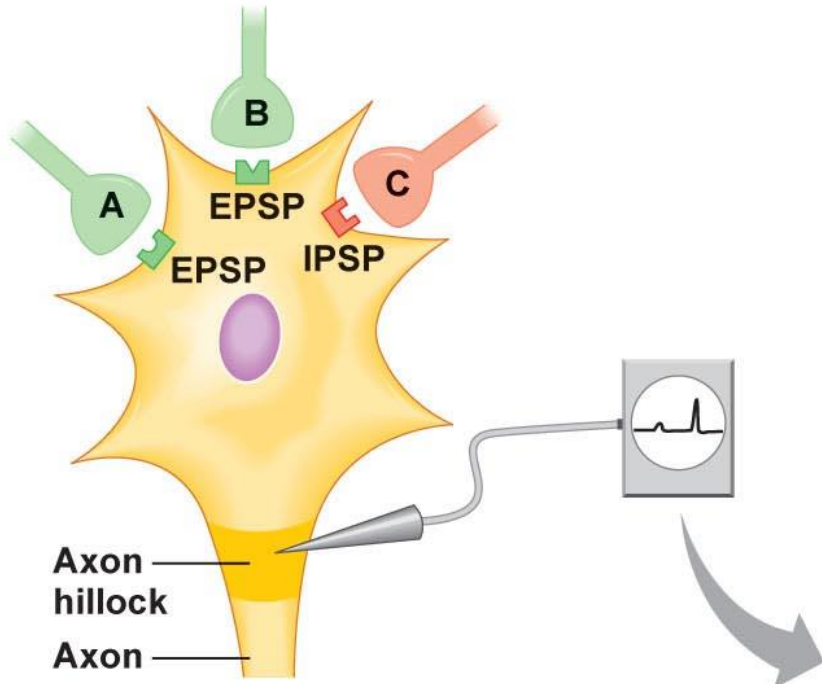


PSP'lerin toplanması

1. EPSP – uyarıcı veya eksitator postsinaptik potansiyel

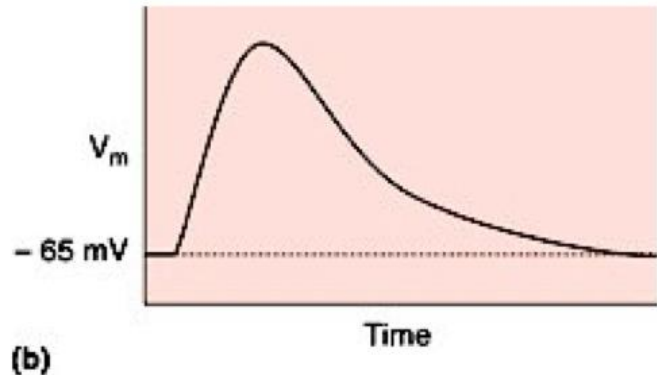
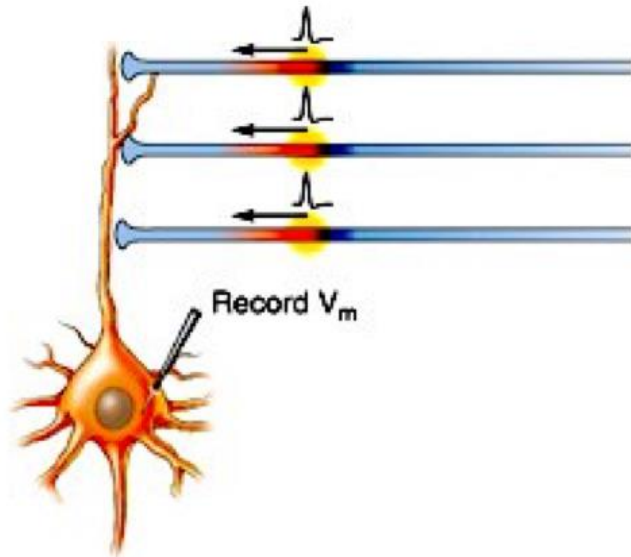


PSP'lerin toplanması

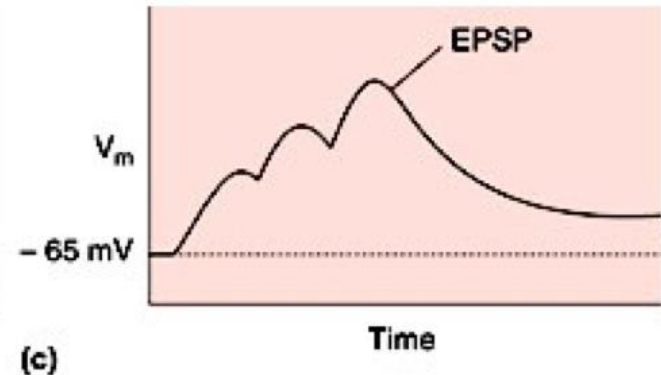
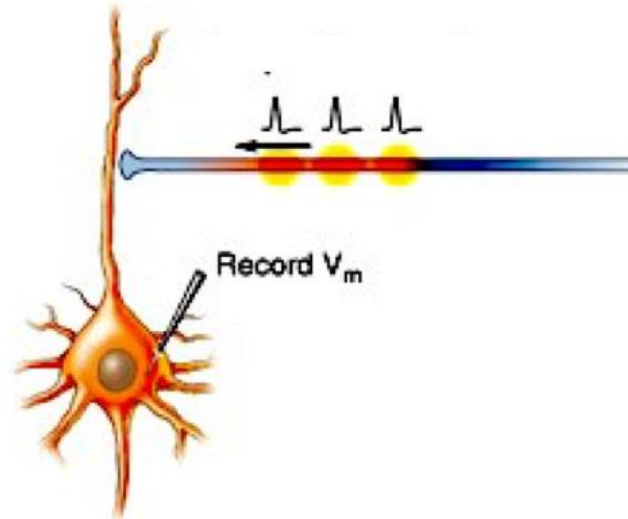


- Aynı nöronun birbirine yakın süreler ile gelen uyarıları- zamansal toplanma (**temporal summation**)
- Bir nöronun farklı sinapslarından gelen uyarı- uzamsal toplanması (**spatial summation**)

Spatial summation:
several different pre-synaptic neurons firing
(at same time) at
different synapses

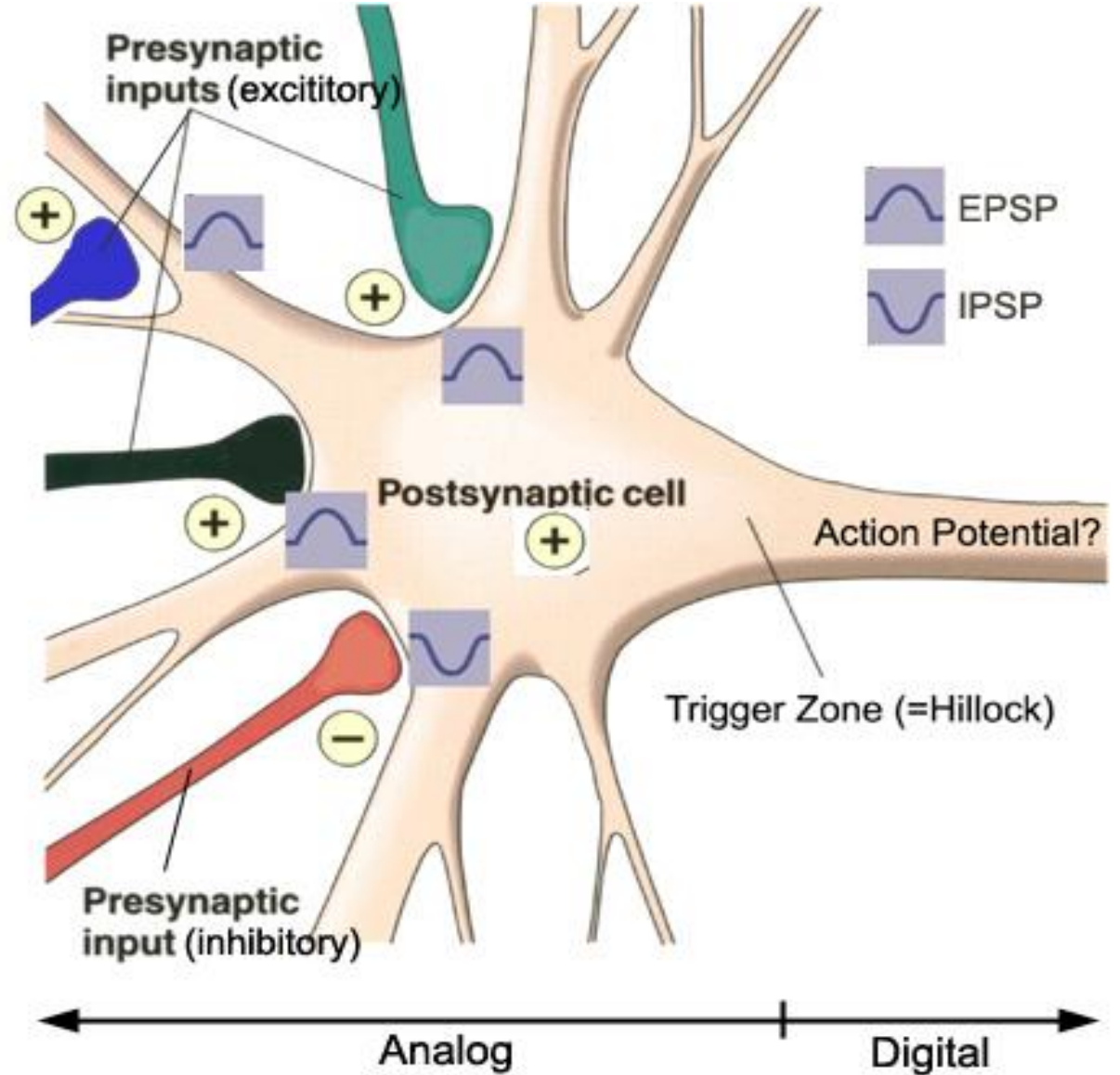


Temporal summation:
same or nearby pre-synaptic neuron firing
multiple times in close
succession

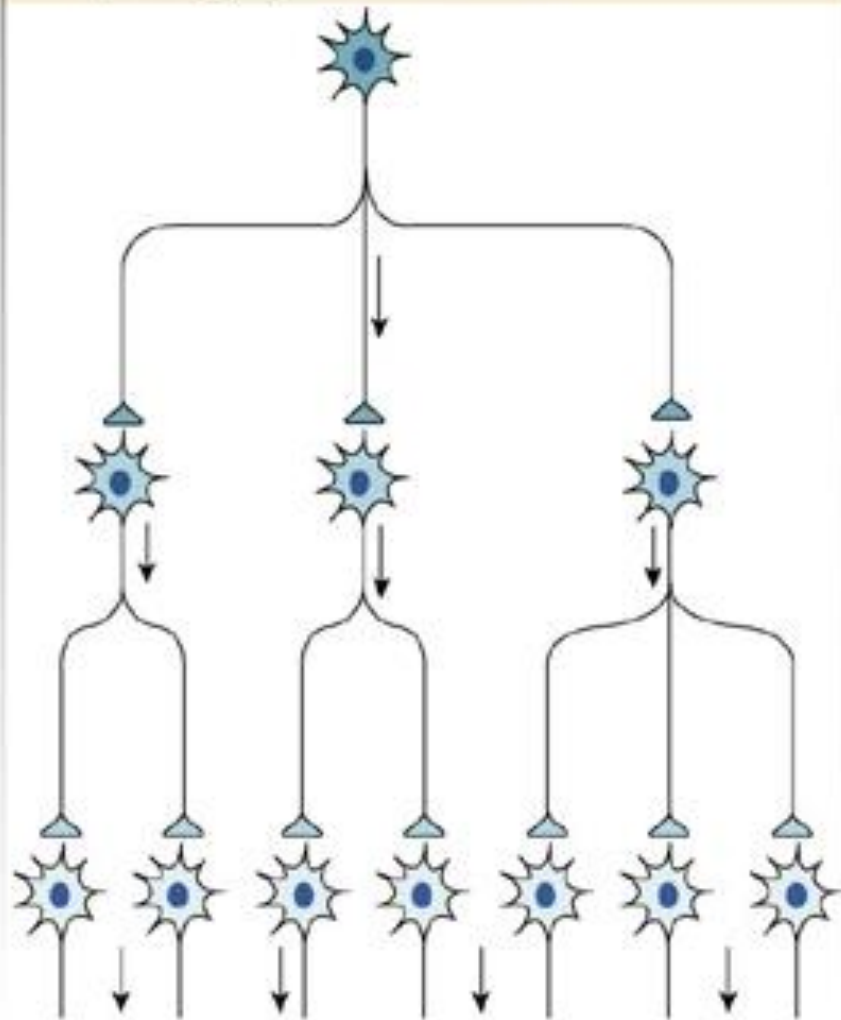


Synaptik integrasyon

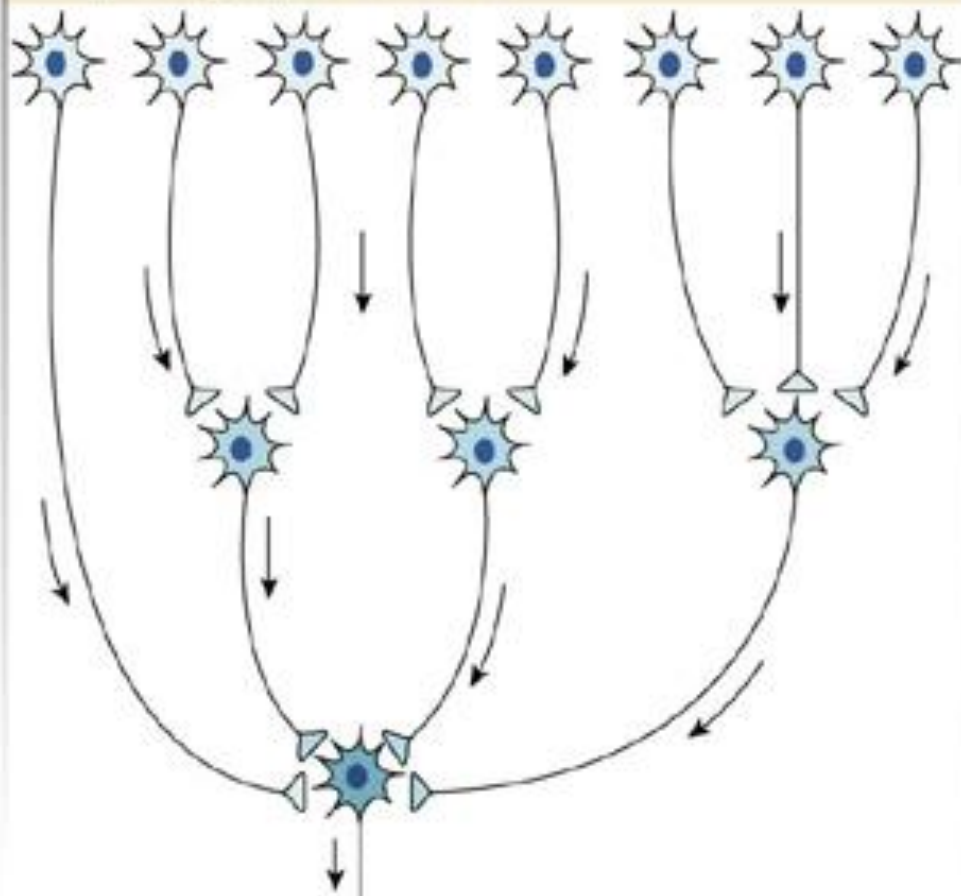
- Bir nöronda toplam EPSP ve IPSP'lerin kombinasyonu
- Bir AP'nin oluşabilmesi için **tetikleme bölgesindeki potansiyelin eşik değere ulaşması gerekir.**



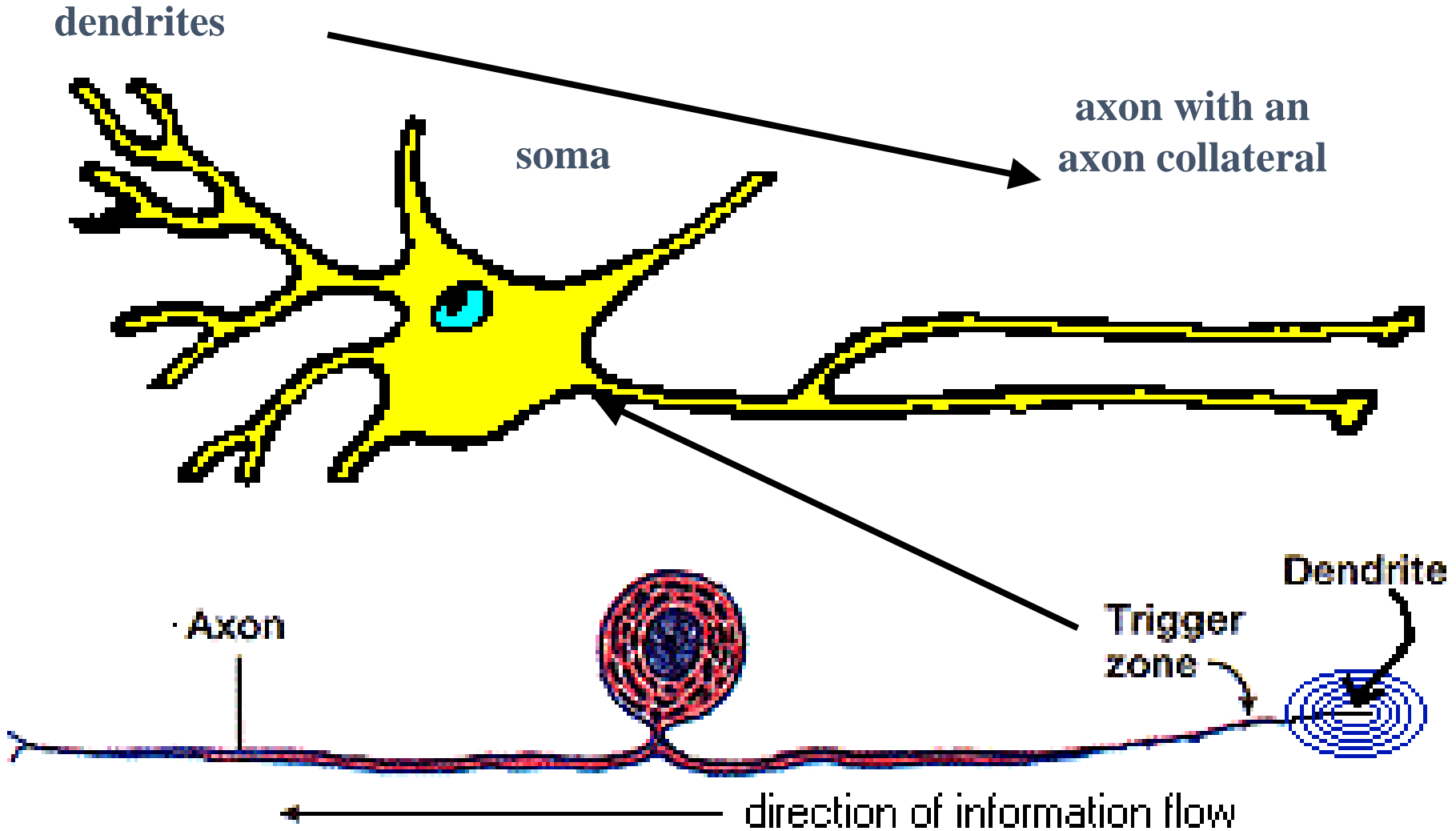
(a) In a divergent pathway, one presynaptic neuron branches to affect a larger number of postsynaptic neurons.



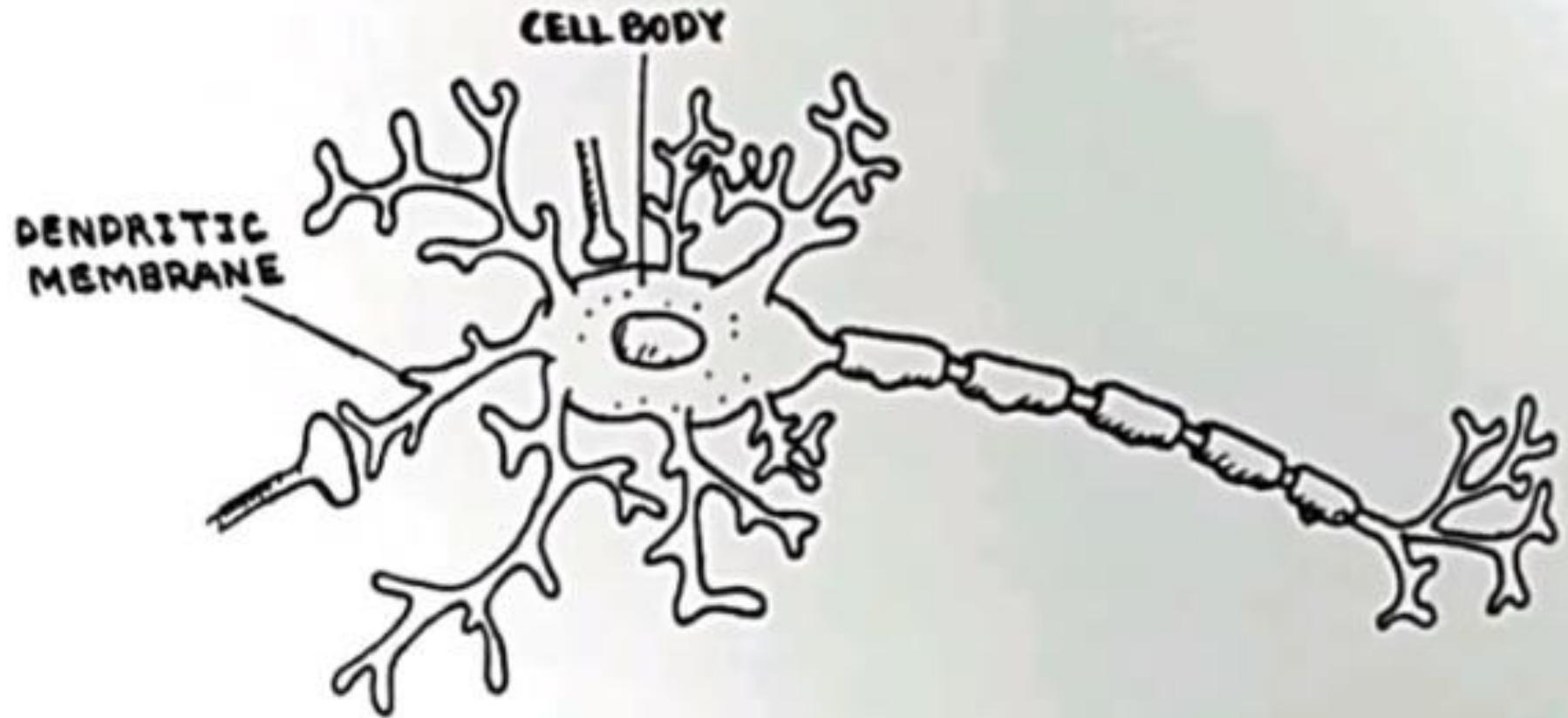
(b) In a convergent pathway, many presynaptic neurons converge to influence a smaller number of postsynaptic neurons.

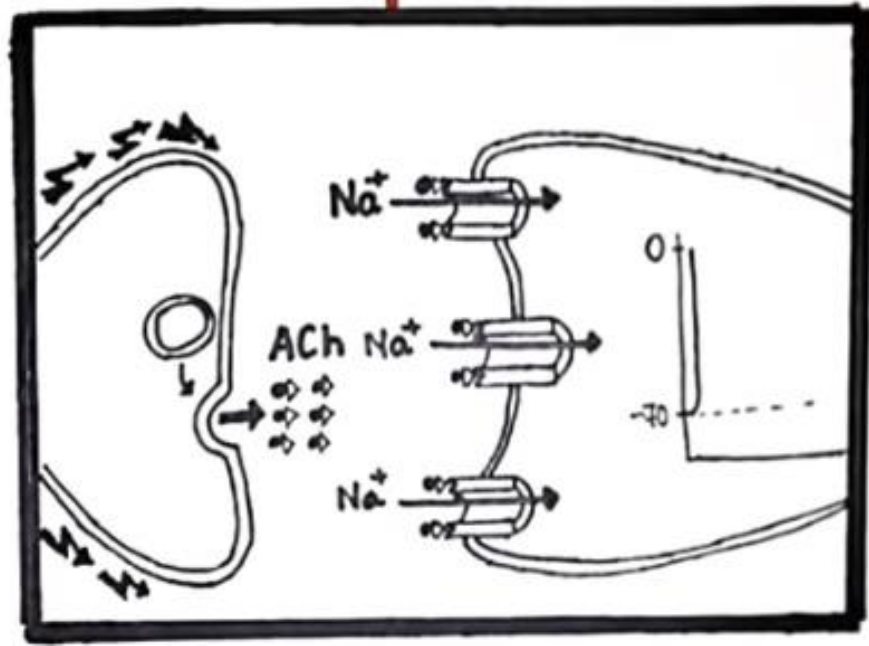
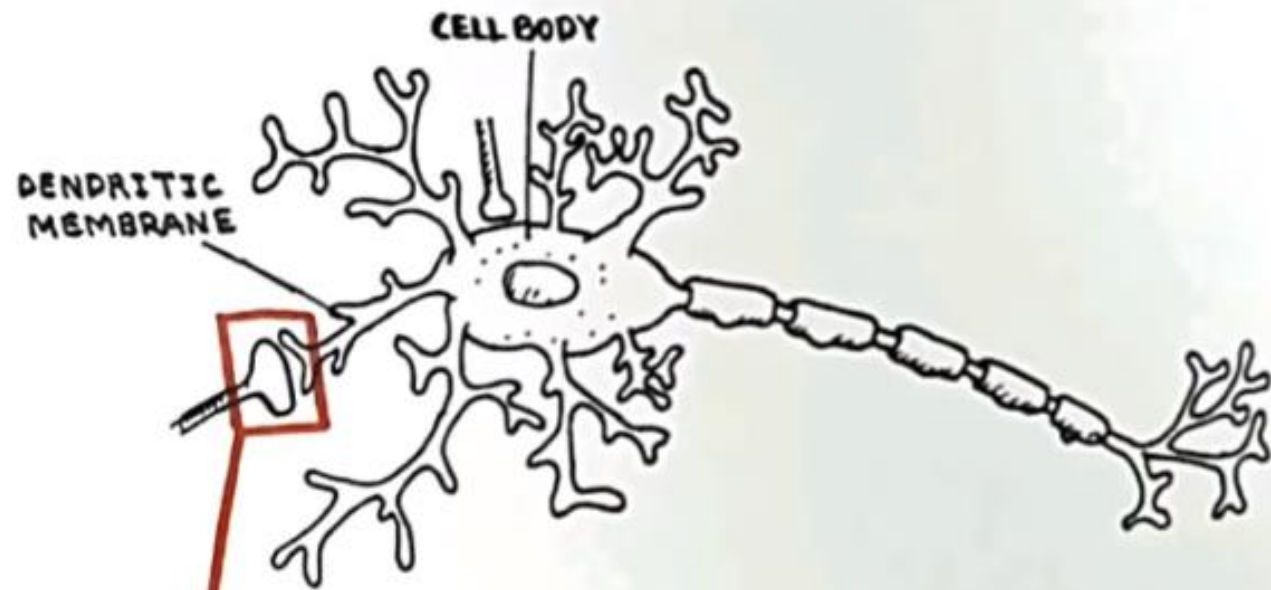


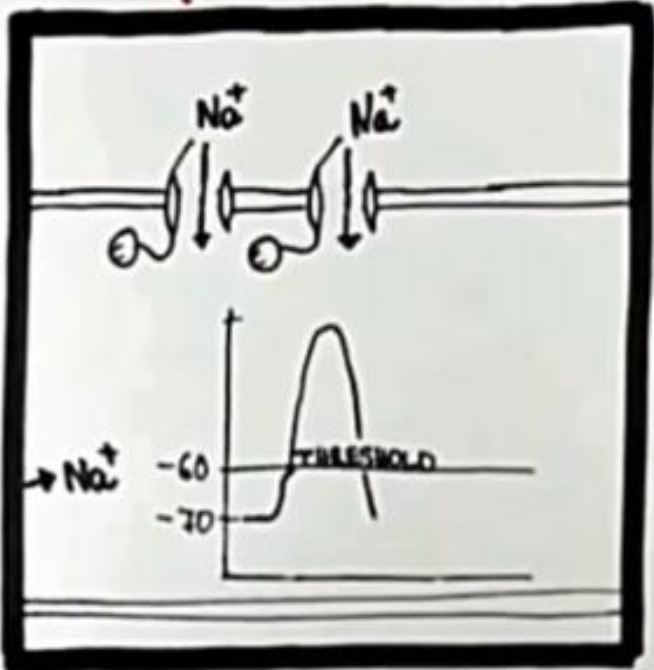
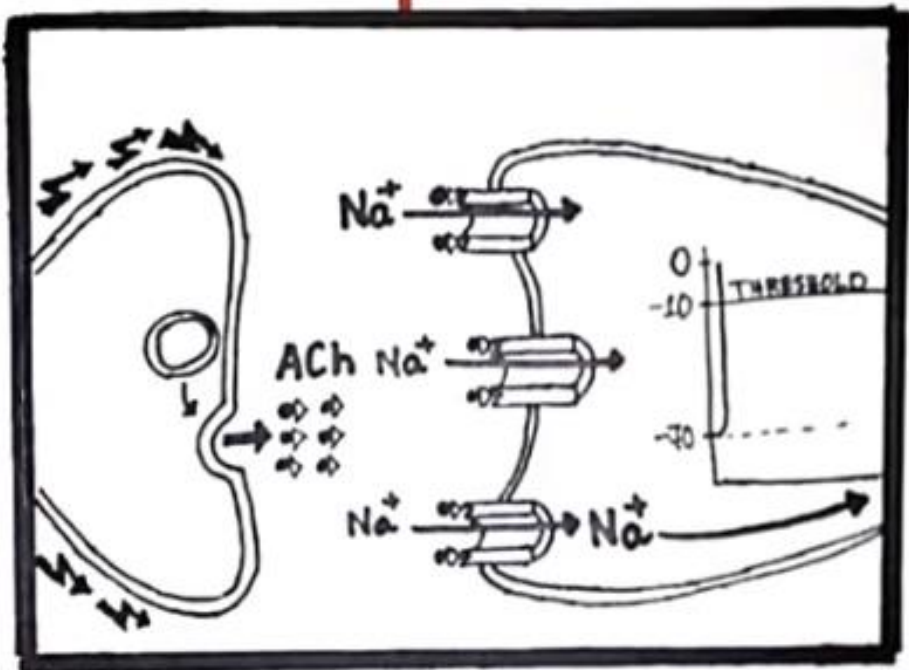
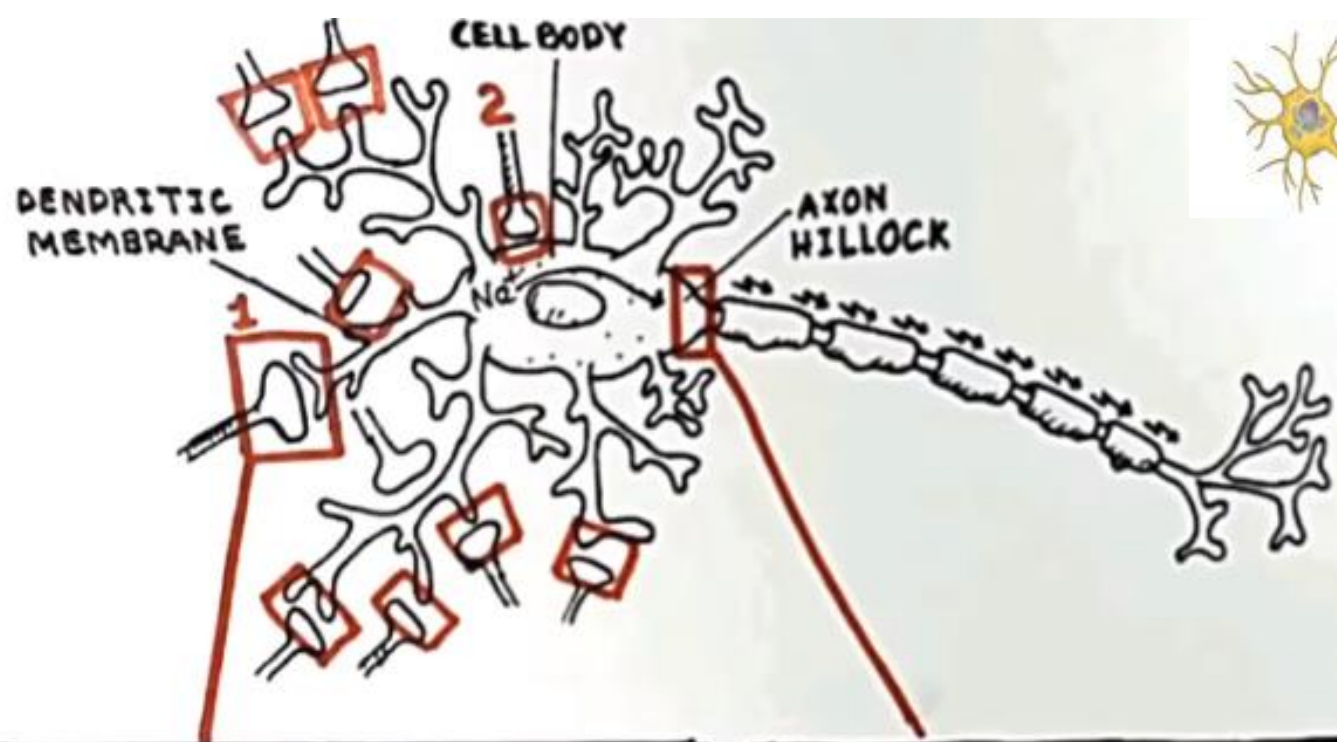
Aksiyon potansiyelinin oluşumu

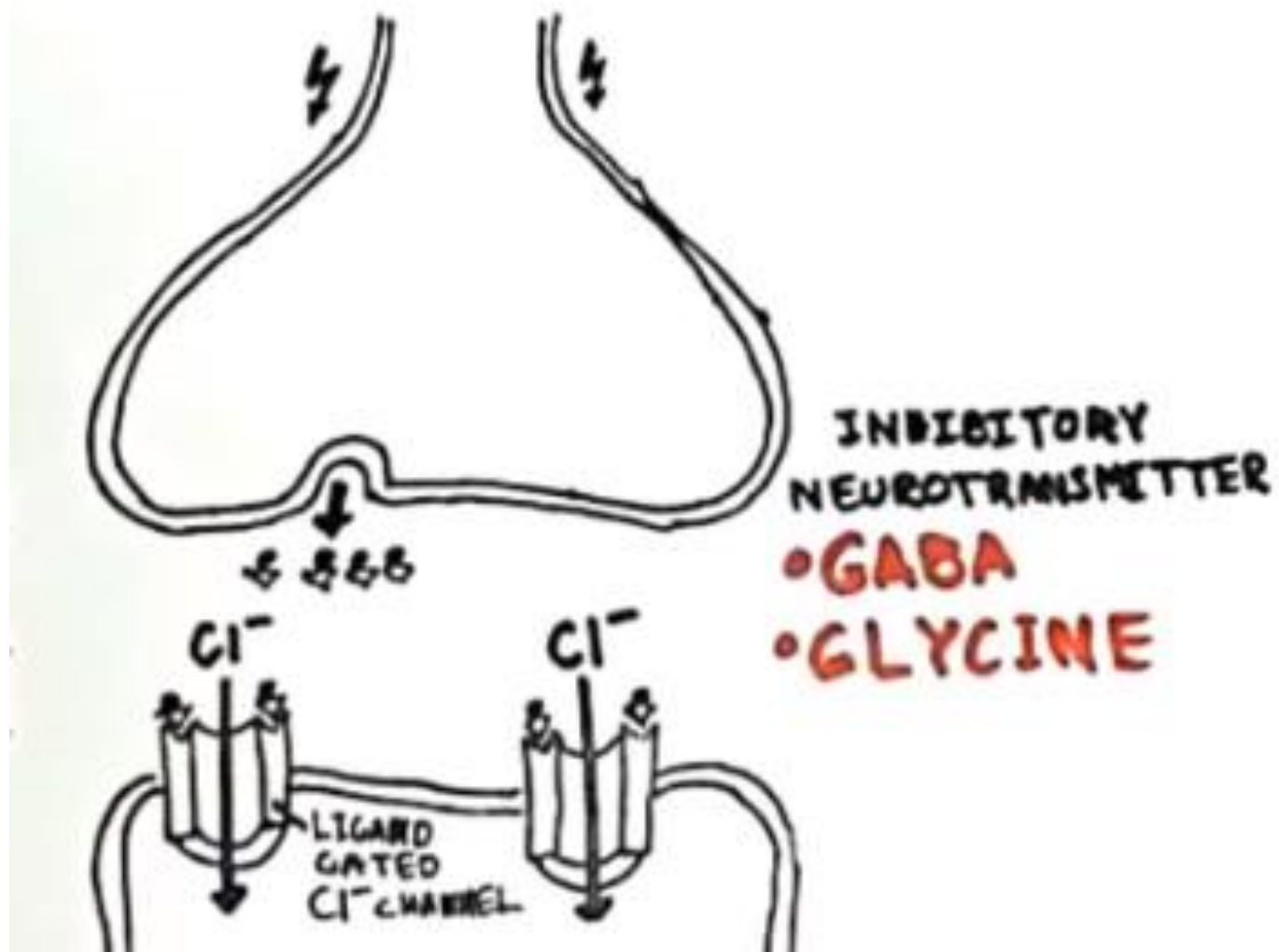
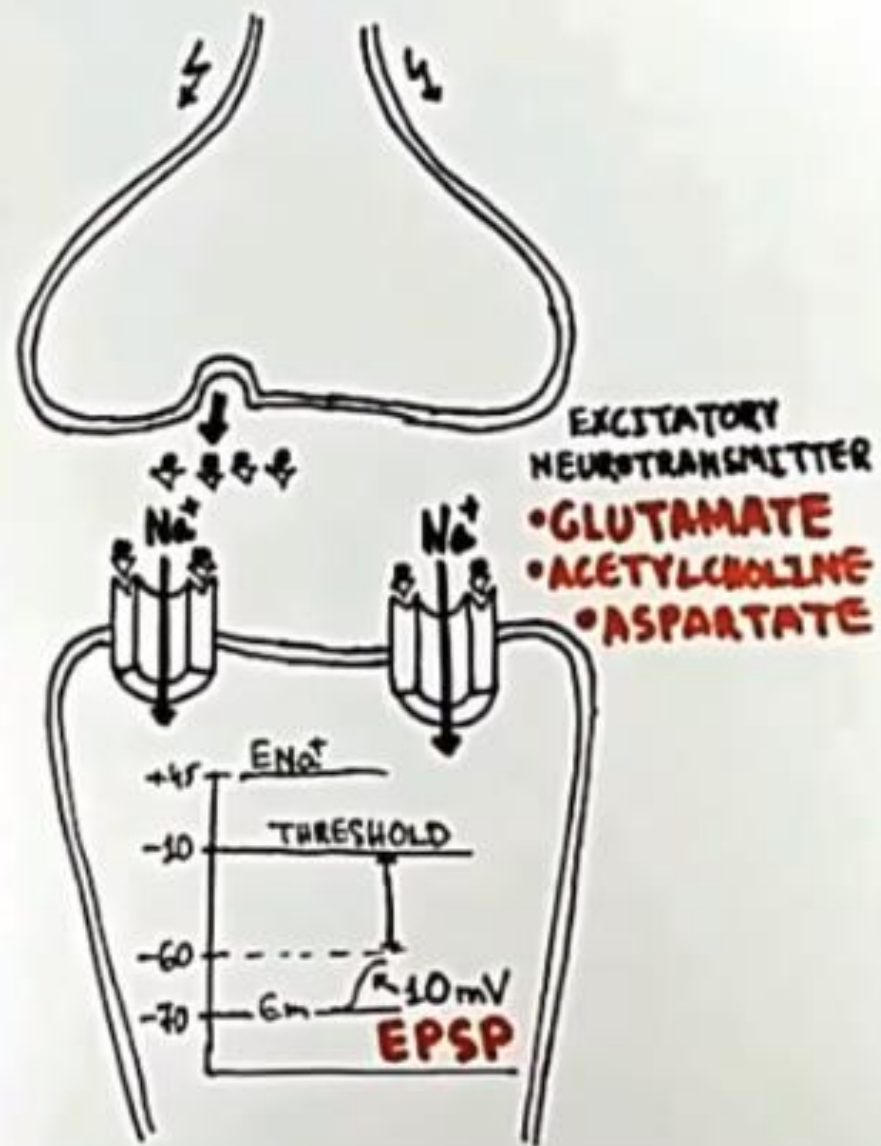


NEURON-NEURON SYNAPSES

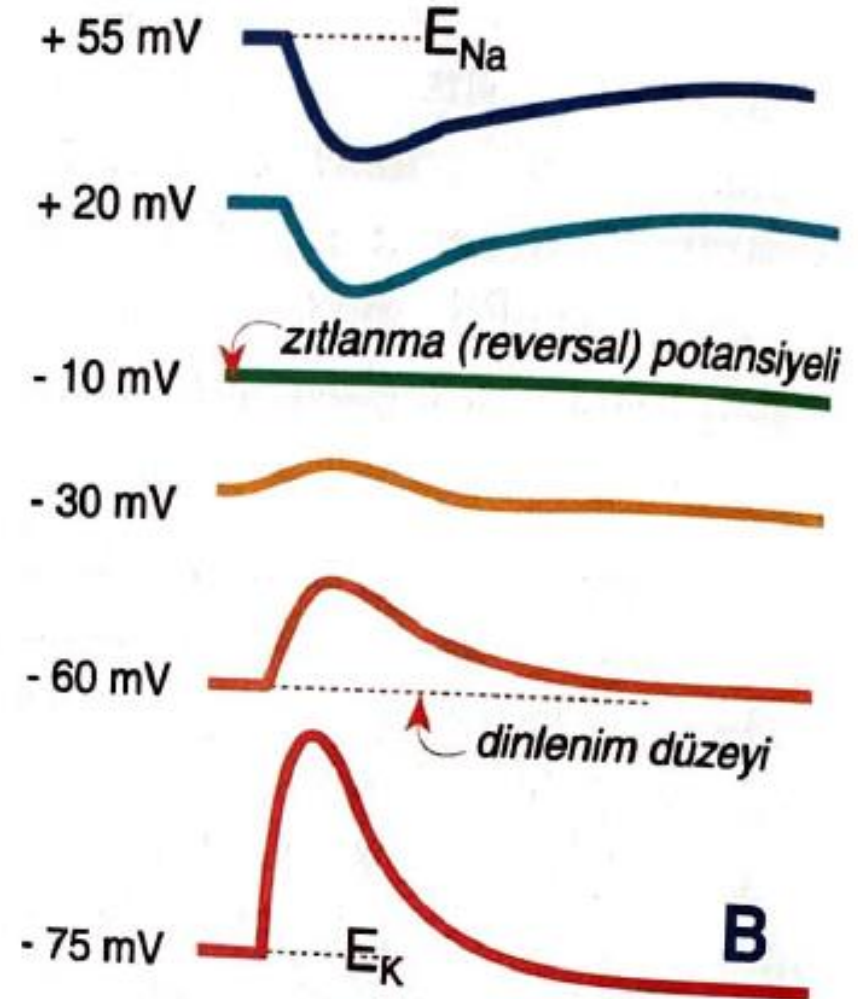
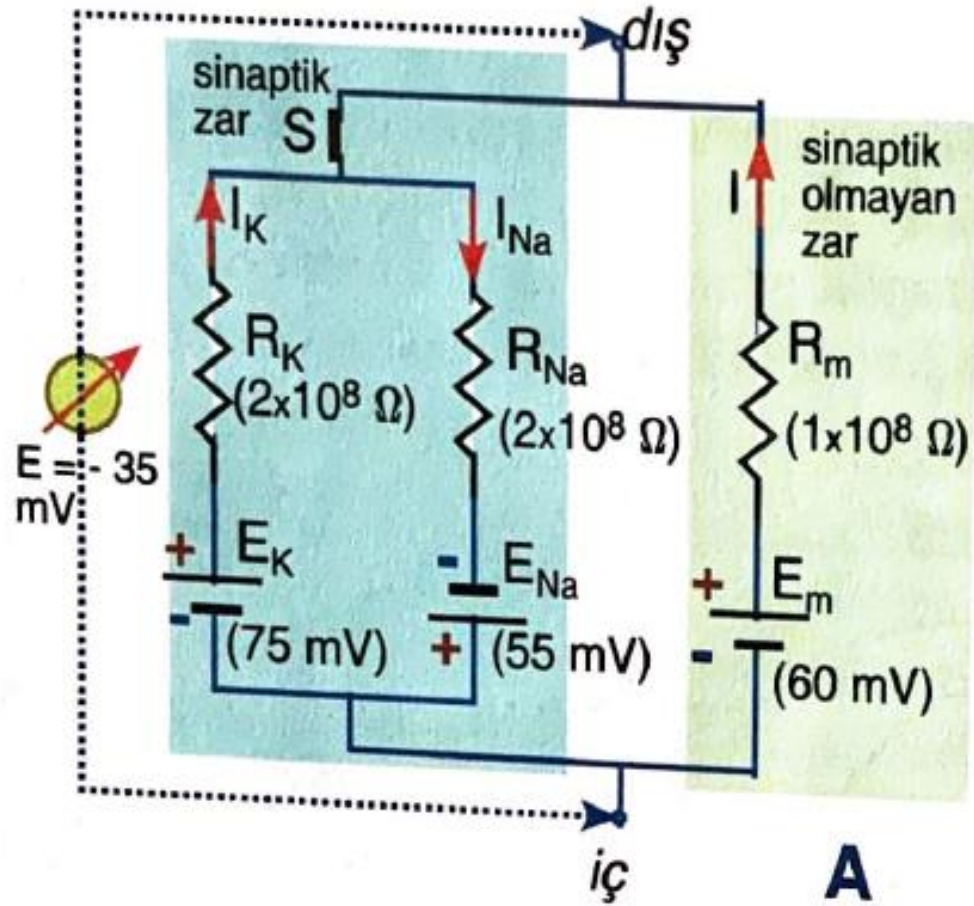






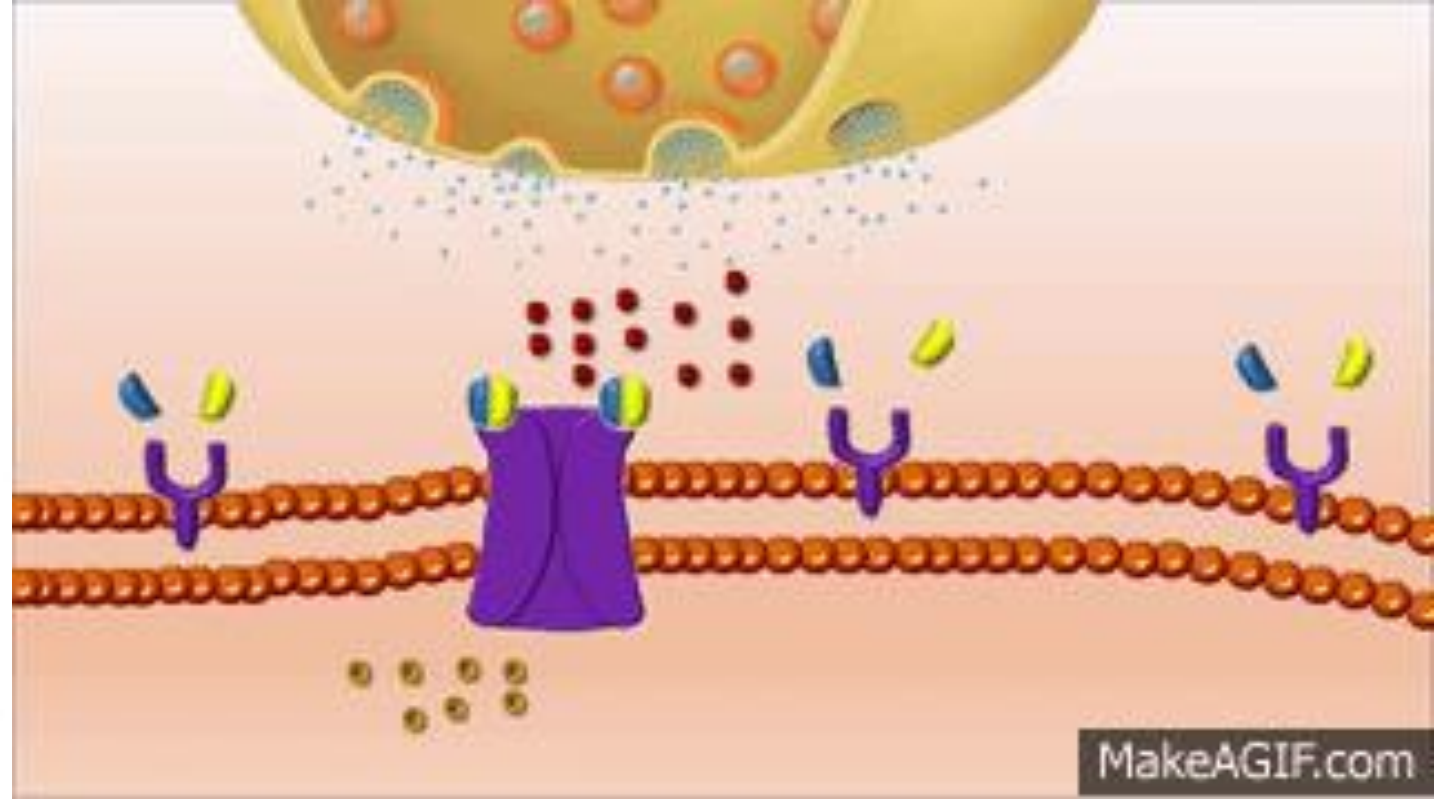
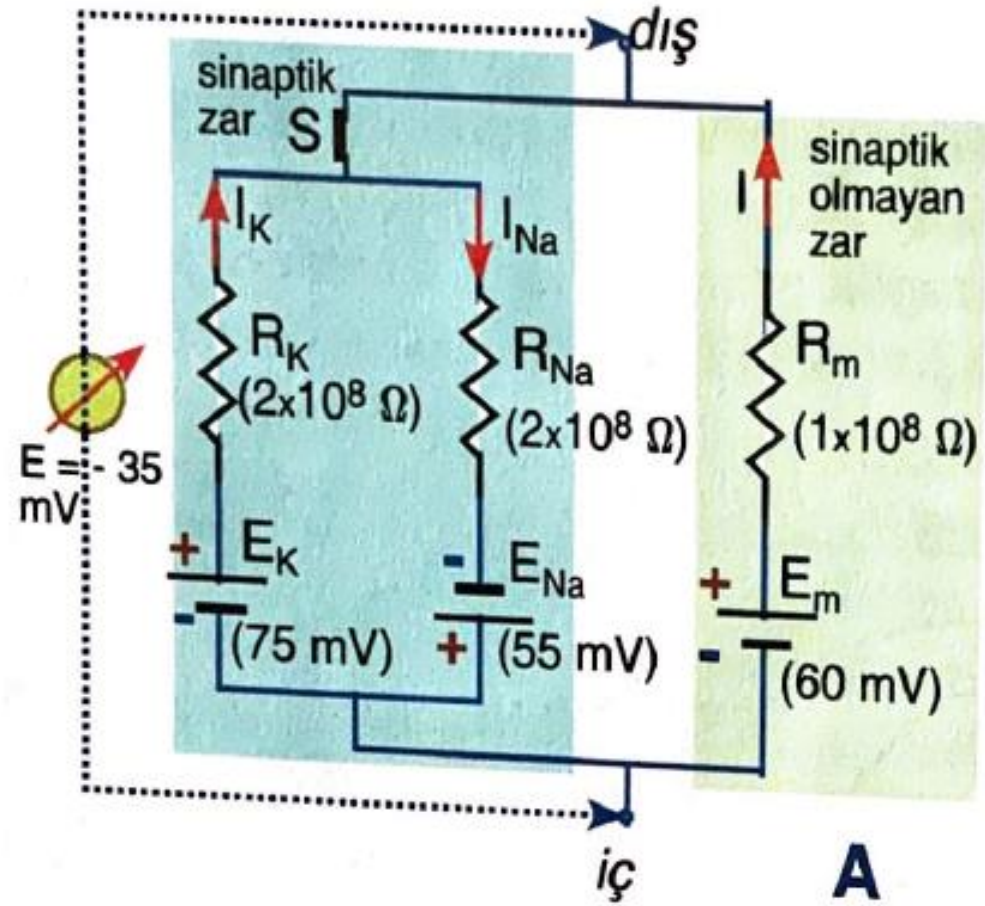


Uyarıcı bir Sinaptik İletim için Elektriksel Eşdeğer Devre



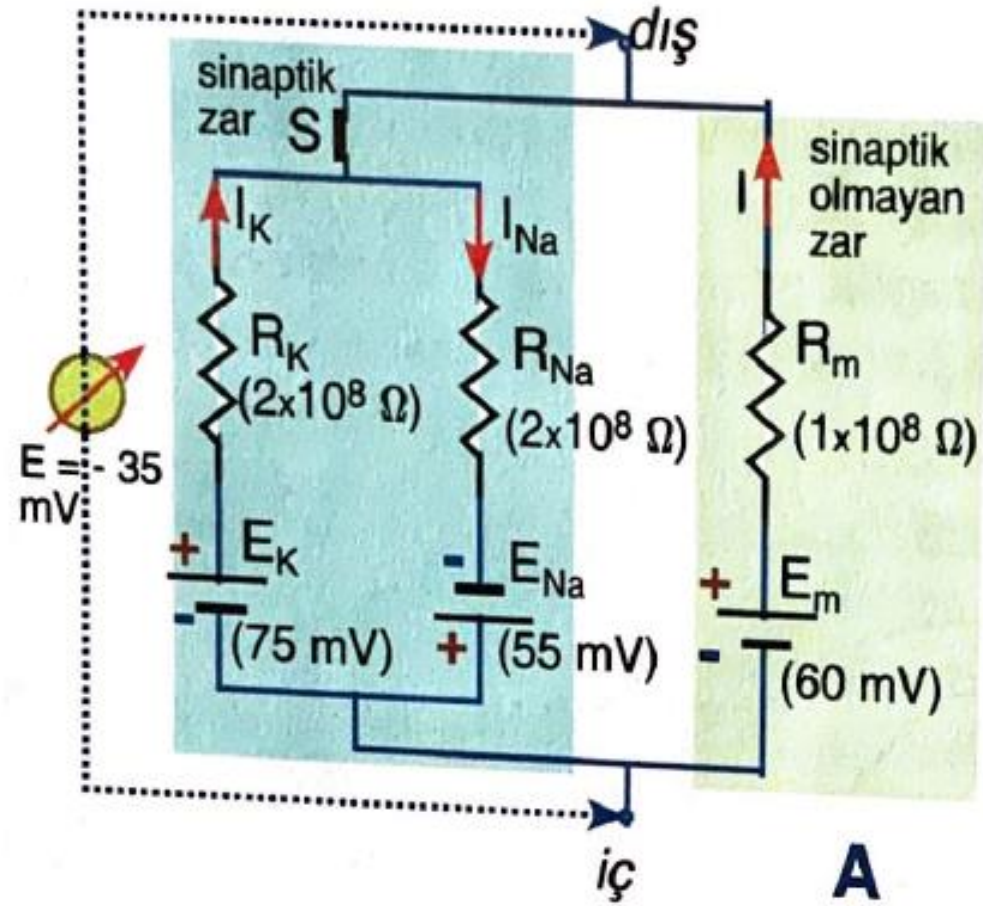
Dinlenme membran potansiyeli=-60mV olsun

Uyarıcı bir Sinaptik İletim için Elektriksel Eşdeğer Devre



Dinlenim membran potansiyeli=-60mV olsun

Uyarıcı bir Sinaptik İletim için Elektriksel Eşdeğer Devre



Dinlenim membran potansiyeli = -60 mV olsun

$$\begin{aligned} \Sigma E = \Sigma RI &\Rightarrow (0,075 + 0,055) = 2 \cdot 10^8 I_K + 2 \cdot 10^8 I_{Na} \\ (0,075 - 0,060) &= 2 \cdot 10^8 I_K - 1 \cdot 10^8 I \\ \Sigma I = 0 &\Rightarrow I_K + I - I_{Na} = 0 \end{aligned}$$

$$I_K = 2 \cdot 10^{-10} \text{ A}, \quad I_{Na} = 4,5 \cdot 10^{-10} \text{ A}, \quad I = 2,5 \cdot 10^{-10} \text{ A}$$

$$\begin{aligned} V_{i\check{c}} - V_{dış} &= \Sigma RI - \Sigma E \\ \Rightarrow V_{i\check{c}} - V_{dış} &= 2 \cdot 10^8 \cdot 2 \cdot 10^{-10} - 0,075 \\ \Rightarrow V_{i\check{c}} - V_{dış} &= -35 \text{ mV} \end{aligned}$$

Uyarıcı bir Sinaptik İletim için Elektriksel Eşdeğer Devre

$$I_{Na} = g_{Na}(E_m - E_{Na}) \quad I_K = g_K(E_m - E_K)$$

Zar potansiyelinin zıtlanma potansiyeline eşit olması durumunda;

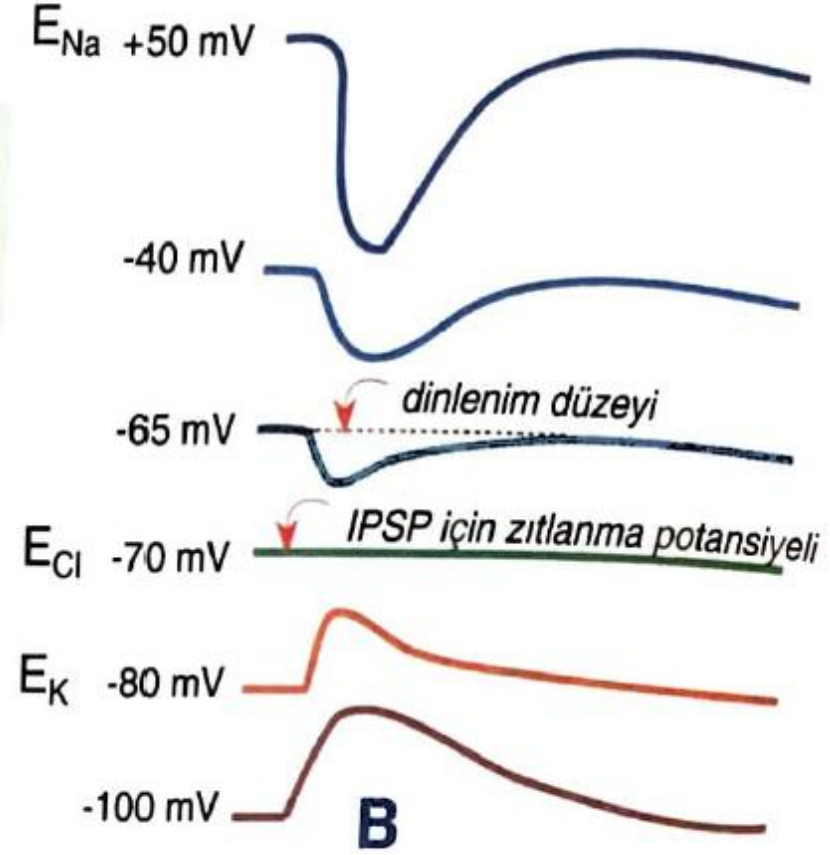
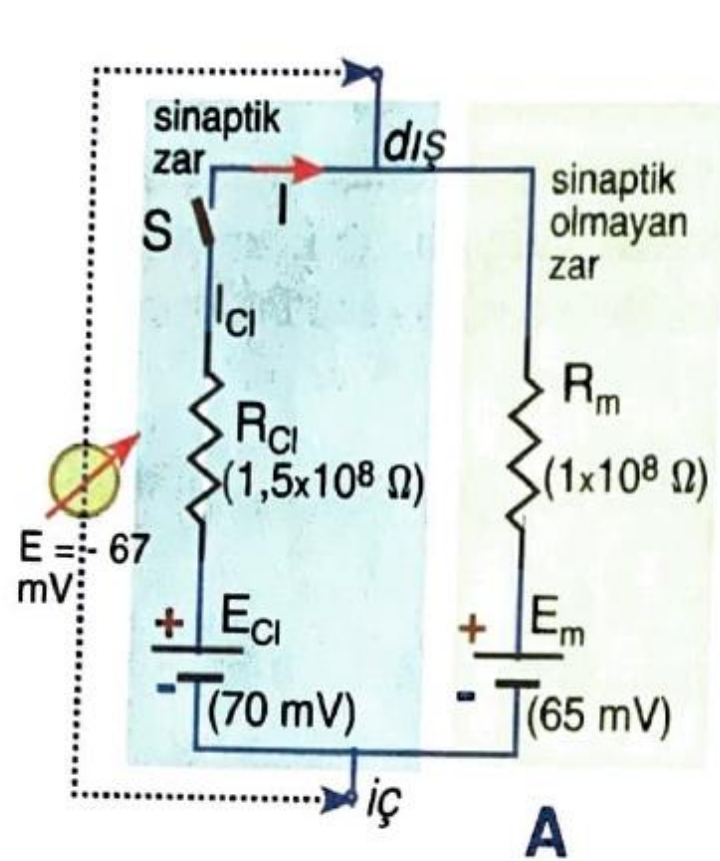
$$I_{Na} + I_K = g_{Na}(E_{EPSP} - E_{Na}) + g_K(E_{EPSP} - E_K) = 0$$

$$E_{EPSP} = \frac{(g_{Na}E_{Na}) + (g_K E_K)}{g_{Na} + g_K}$$

$g_{Na} = g_K$ ise; $E_{EPSP} = (E_{Na} + E_K)/2$ olur

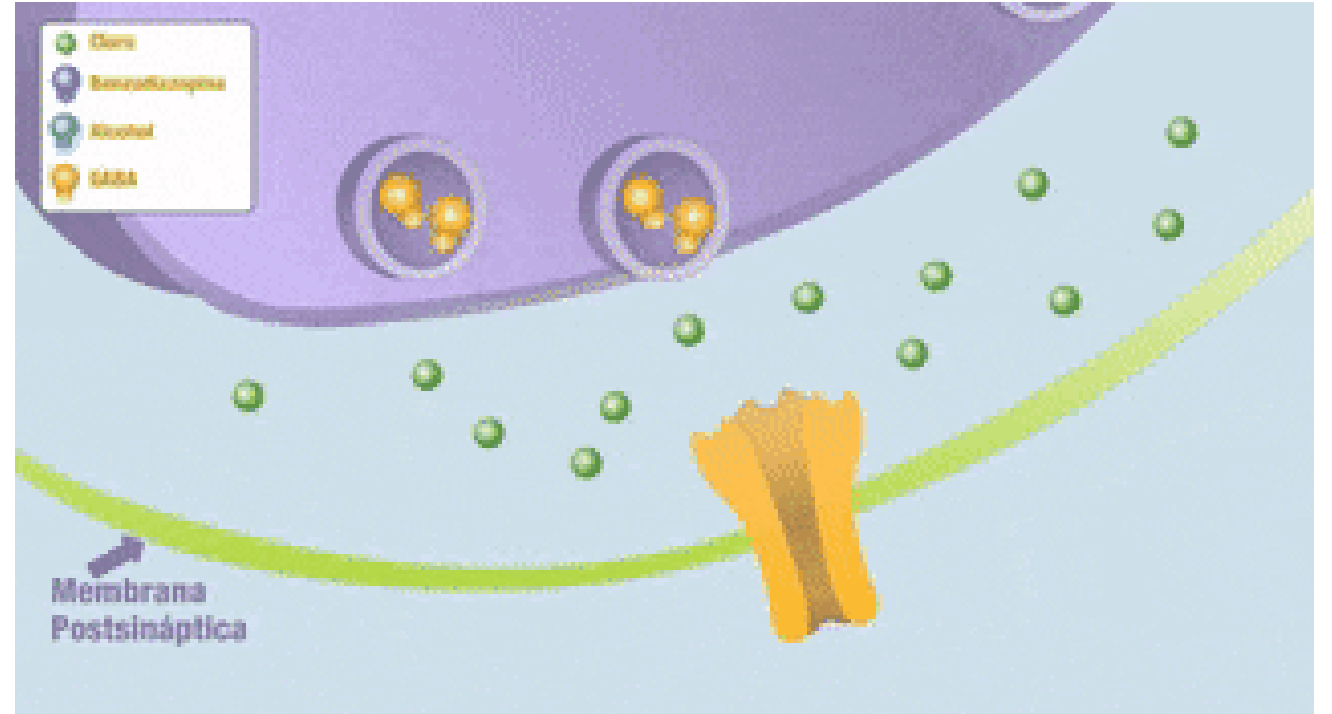
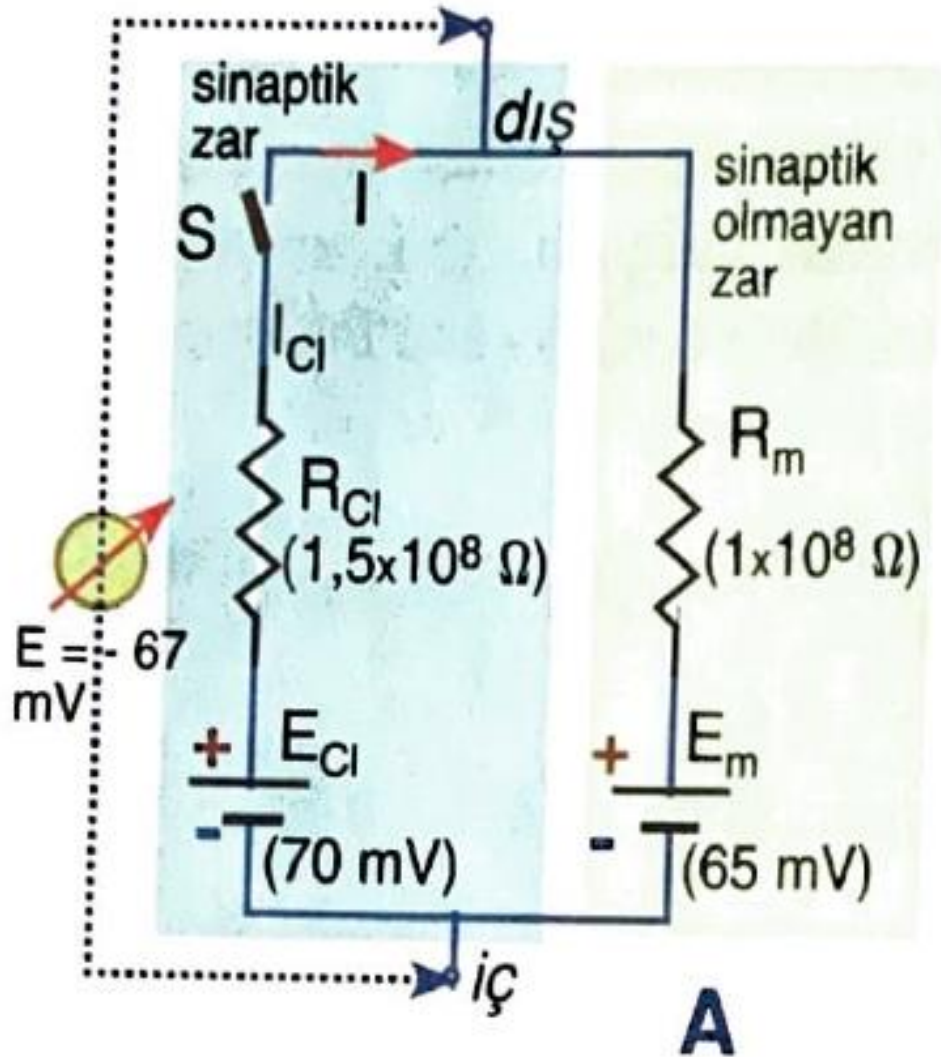
$E_{EPSP} = (+55 + (-75))/2 = -10\text{mV}$ bulunur

Engelleyici bir Sinaptik İletim için Elektriksel Eşdeğer Devre



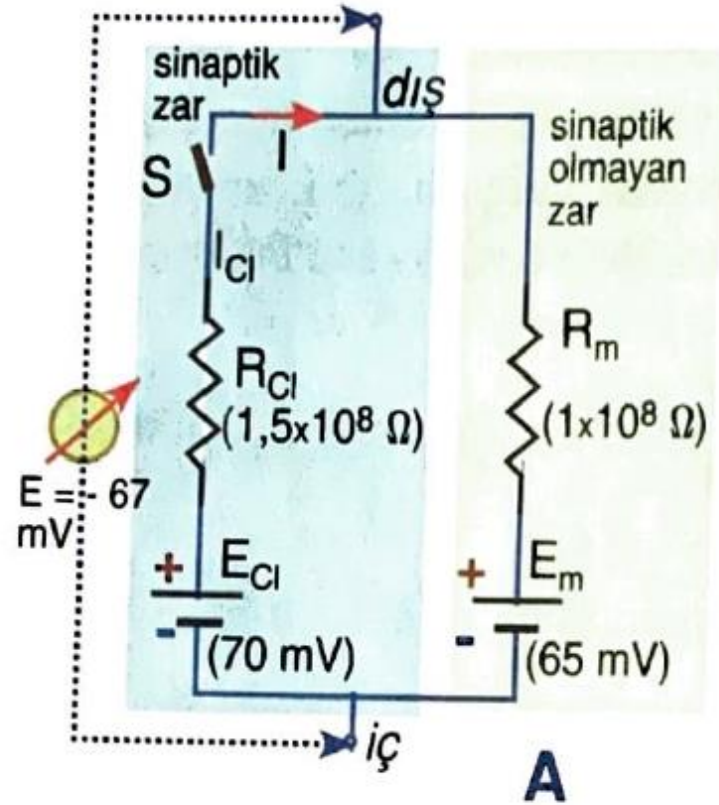
Dinlenme membran potansiyeli = -60 mV olsun

Engelleyici bir Sinaptik İletim için Elektriksel Eşdeğer Devre



Dinlenim membran potansiyeli=-65mV olsun

Engelleyici bir Sinaptik İletim için Elektriksel Eşdeğer Devre



$$\sum E = \sum RI \Rightarrow$$

$$75 \cdot 10^{-3} - 65 \cdot 10^{-3} = 2,5 \cdot 10^8 I \Rightarrow$$

$$I = 2 \cdot 10^{-11} \text{ A}$$

$$V_{iç} - V_{dış} = \sum RI - \sum E$$

$$\Rightarrow V_{iç} - V_{dış} = 1,5 \cdot 10^8 \cdot 2 \cdot 10^{-11} - 0,070$$

$$\Rightarrow V_{iç} - V_{dış} = -67 \text{ mV}$$



Kaynaklar:

- **Pehlivan F. Biyofizik, Ankara Hacettepe-Taş, 2015**
- Kandel E.R., Schwartz J.H, Jessel T.M. .(Eds). Principles of Neural Science, New York; Elsevier (2002).
- Ganong W.F. Tibbi Fizyoloji, Barış kitabevi, 1996
- Guyton A.C, Hall J.E. Tibbi Fizyoloji, Nobel Tıp, 2000