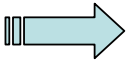
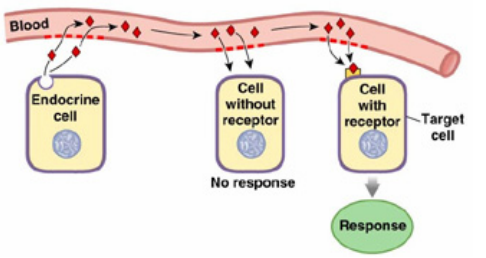
Characteristics of Life

1. Reproduction
2. Structure and function
3. Metabolism
4. Growth
5. Control and regulation
6. Interaction with environment
7. Adaptation
8. Others.

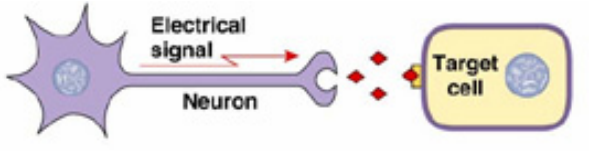
 *Bioinformation*

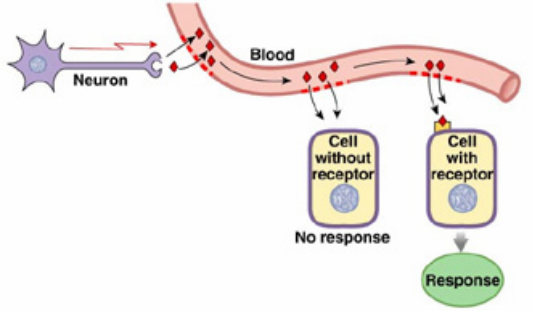
Types of bioinformation transmission



- Humoral – hormone (endocrine)
- Neural – action potential

** Neuroendocrine*





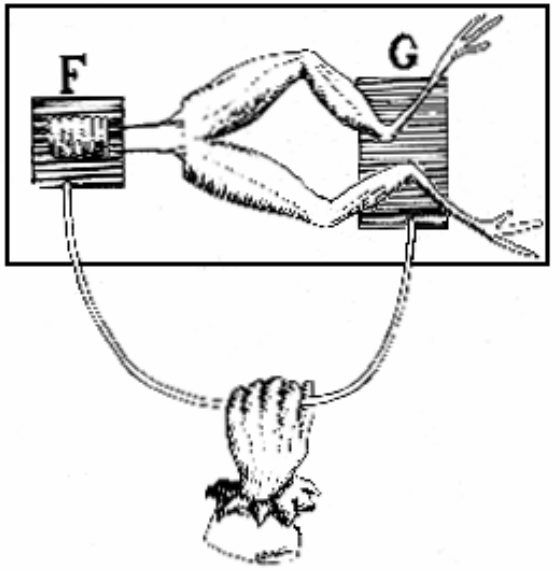
막전압 (membrane potential)

- 세포막전압
- 막전압의 발생
- 안정막전압
- 역치전압
- 활동전압

동물전기 **Aniaml electricity**

Liugi Galvani

(1737-1798)

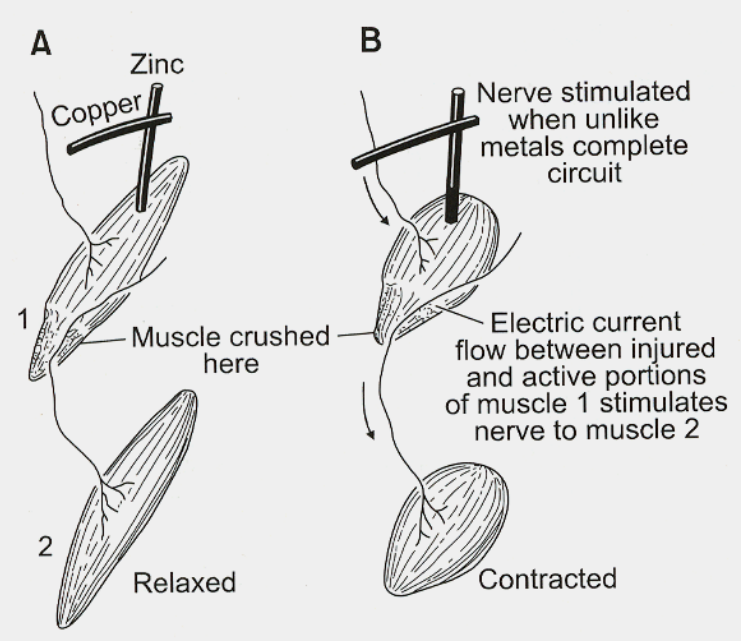


Alessandro Volta
(1745-1827)

Volta 전지

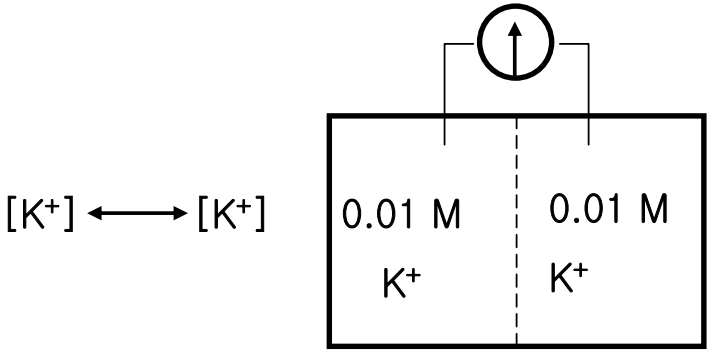
Carlo Matteucci

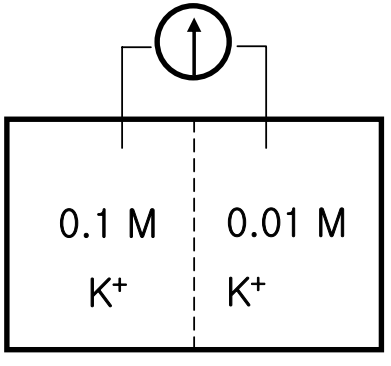
(1811-1868)

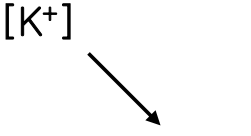


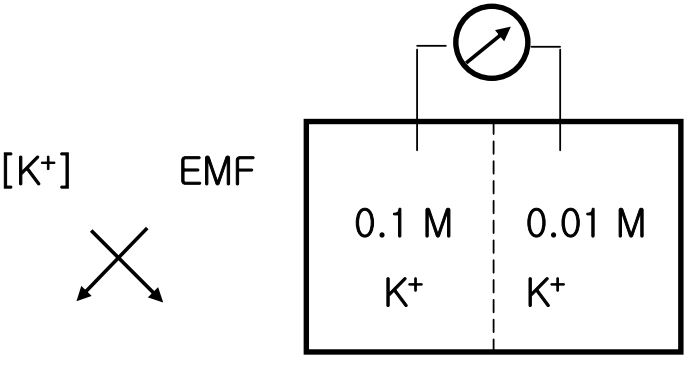
막전압의 생성

- *선택적 투과성*
- *이온의 농도경사*



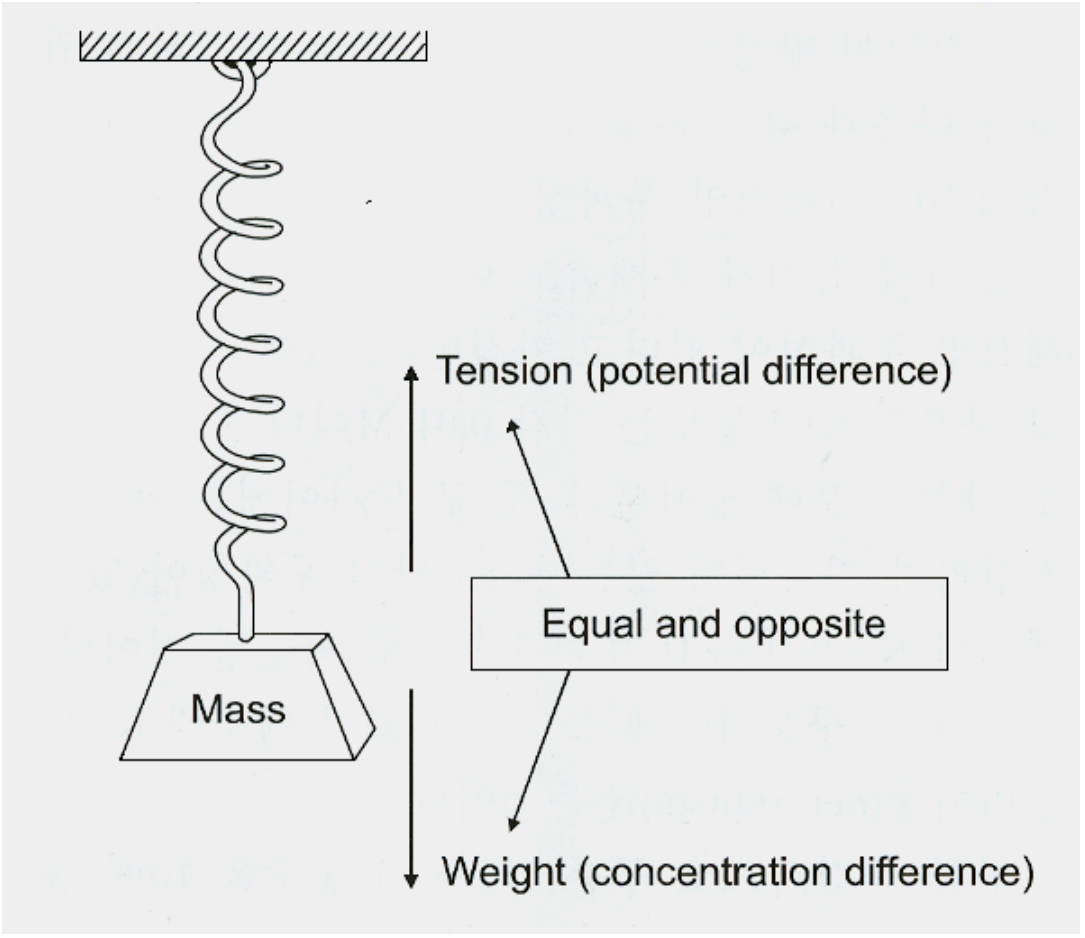






EMF = −(RT/ZF) ln (K_I/K_{II})

= −58 log (K_I/K_{II})

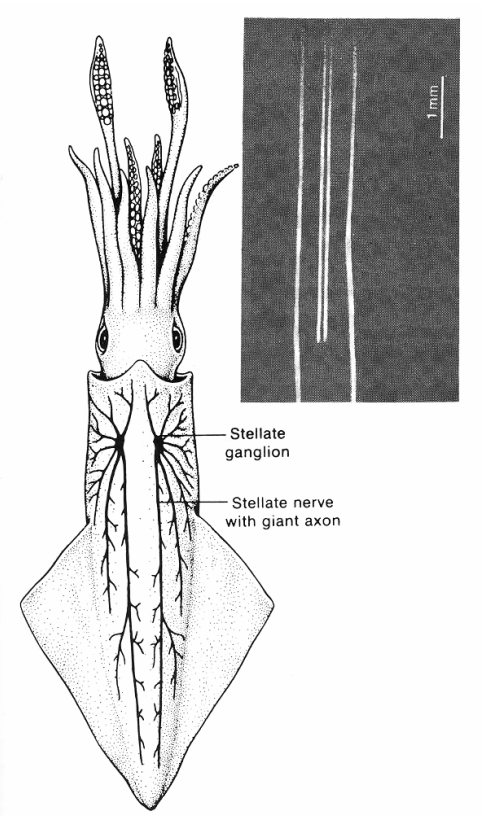

Tension (potential difference)
Equal and opposite
Mass
Weight (concentration difference)

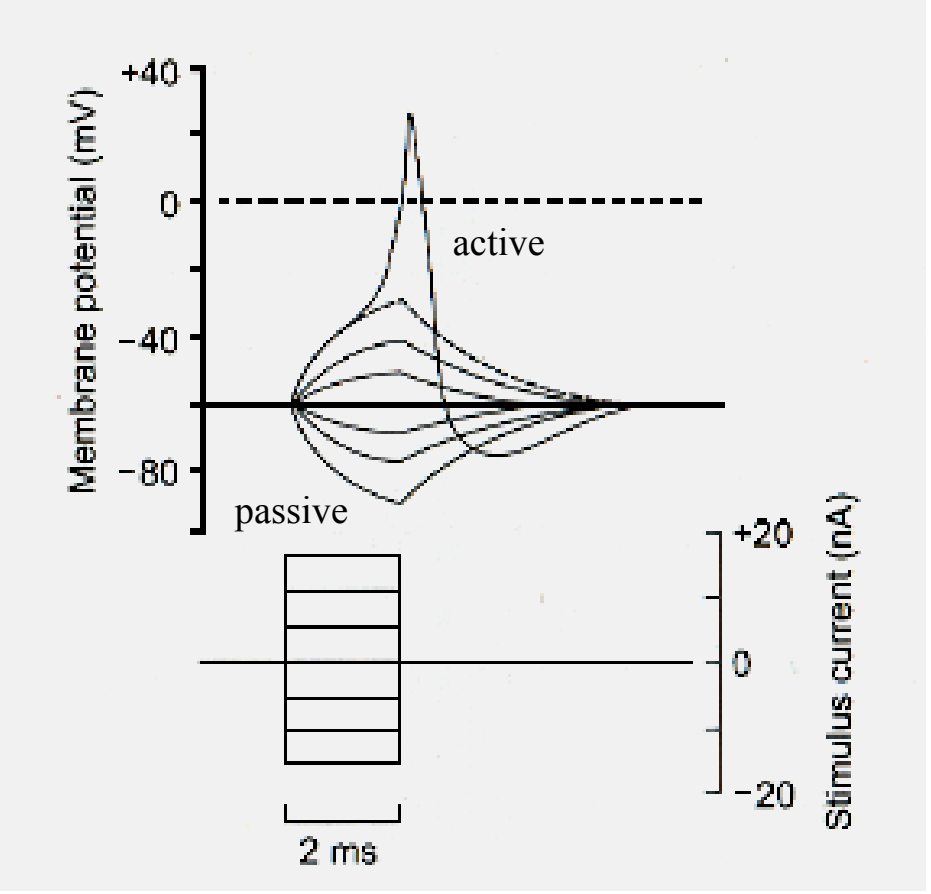
Membrane hypothesis

Julius Bernstein

(1839-1917)

- 세포막 안팎에 K이온 농도에 차이가 있다.
- 세포막은 K에 대한 투과성이 있다.
- 세포안팎에는 전압차가 있다.
- 세포 안팎 전압차는 K의 평형전압에 기인한다.


1 mm
Stellate ganglion
Stellate nerve with giant axon



Active vs

Passive property

Excitation (흥분)

- Threshold (역치)
- Regenerative cycle
- Na and/or Ca channels

흥분성 세포 **excitable cell**

- **막전압**이 변동

 - 활동전압

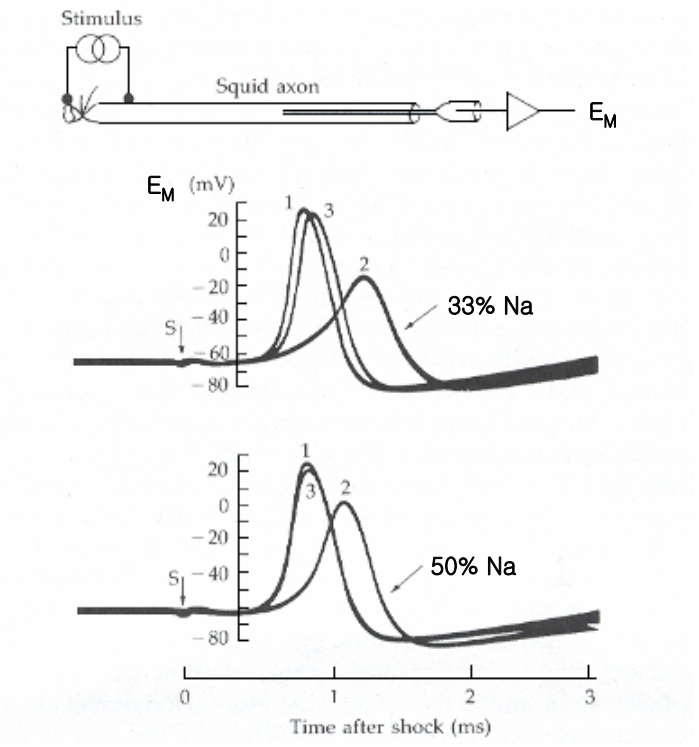
 -- 역치

 -- 전압의존성 통로 Na/Ca통로

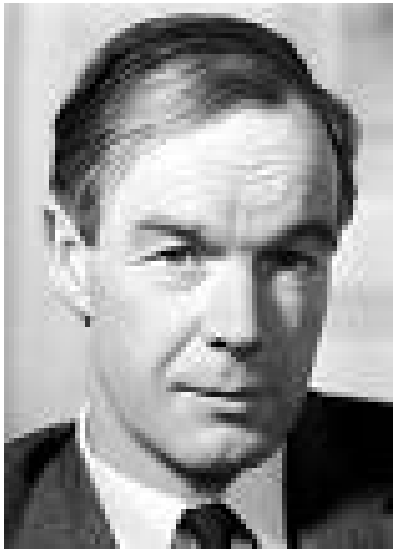
 K통로

- 활동전압으로 그 세포 고유의 활동.

Na 가설

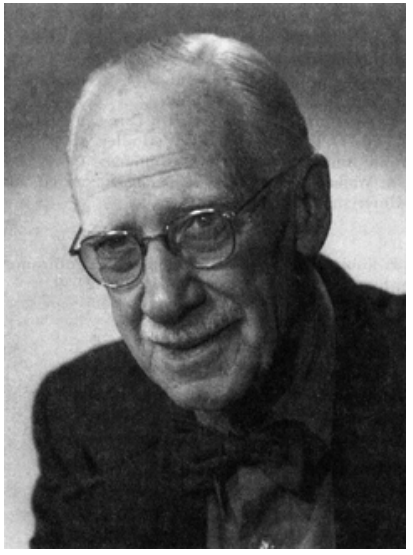


Hodgkin & Katz, 1949



Sir Alan L. Hodgkin

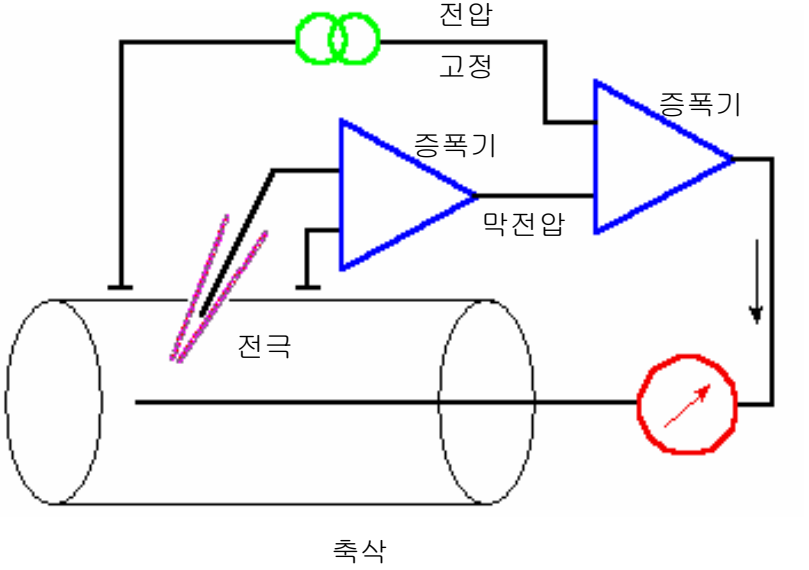
(1914-1998)



Sir Andrew F. Huxley

(1917 -)

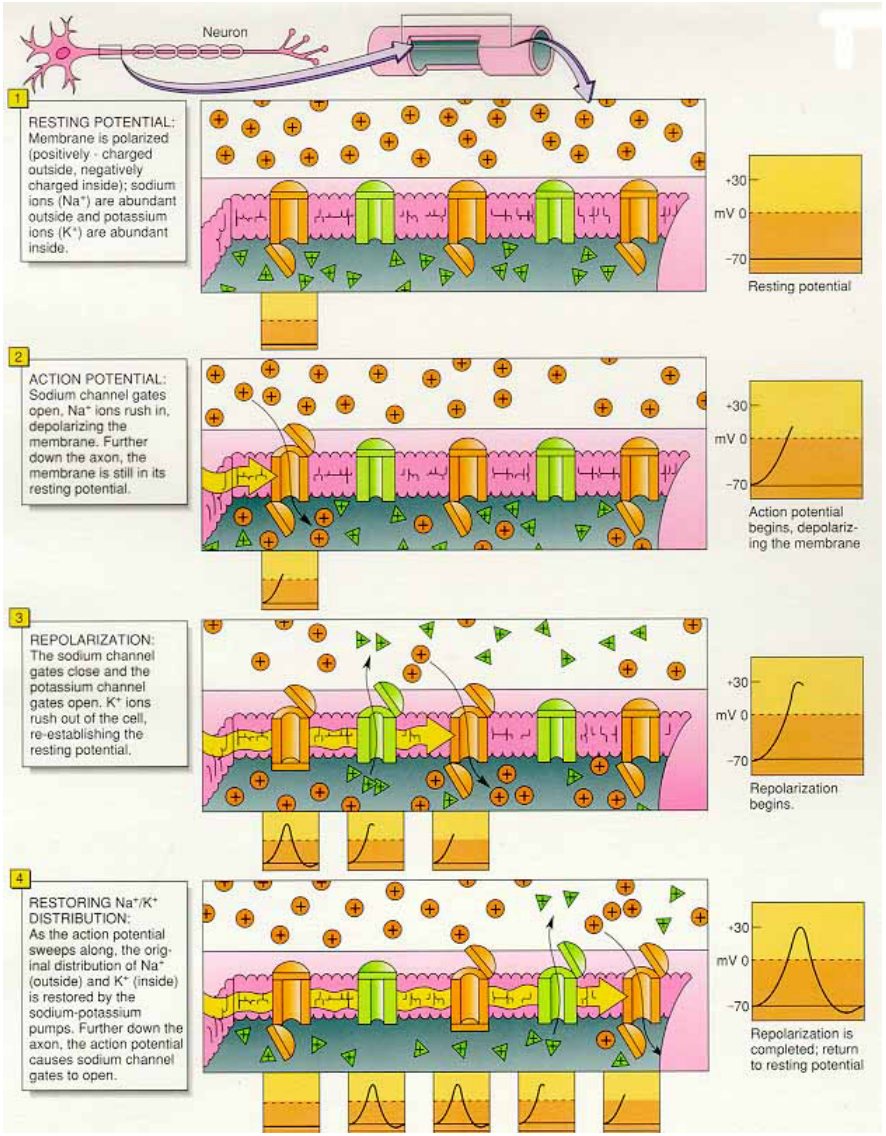
전압고정법Voltage Clamp Technic



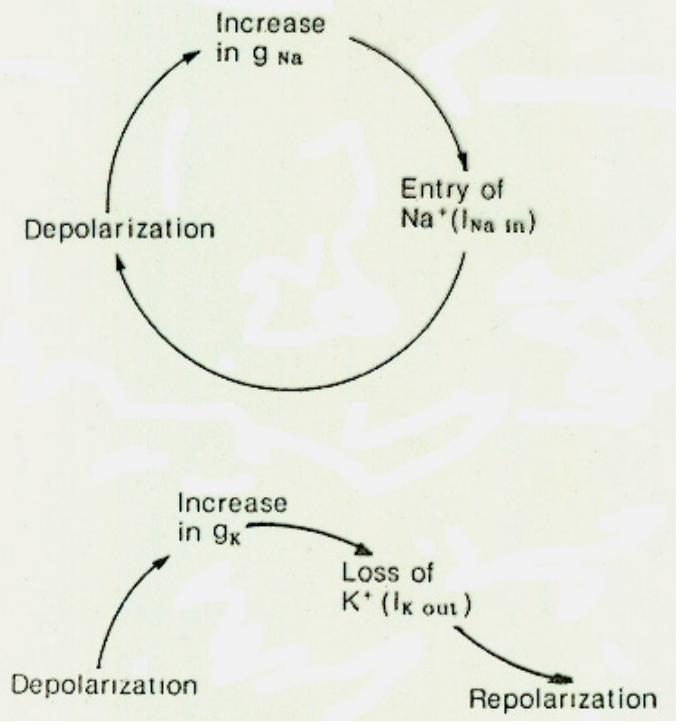
Ohm's law

$$V = I \cdot R$$

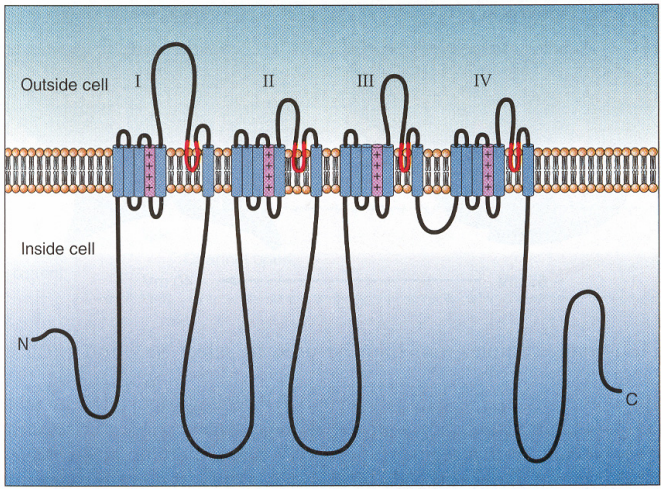
세개의 변수 중 하나를 고정하면 다른 둘 사이의 관계를 알 수 있음.

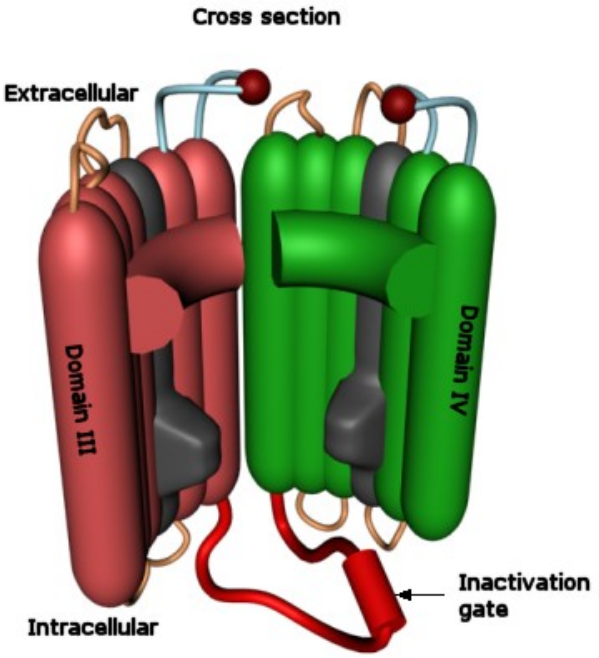

Neuron
1
RESTING POTENTIAL: Membrane is polarized (positively - charged outside, negatively charged inside); sodium ions (Na^+) are abundant outside and potassium ions (K^+) are abundant inside.
+30
mV 0
−70
Resting potential
2
ACTION POTENTIAL: Sodium channel gates open, Na^+ ions rush in, depolarizing the membrane. Further down the axon, the membrane is still in its resting potential.
+30
mV 0
−70
Action potential begins, depolarizing the membrane
3
REPOLARIZATION: The sodium channel gates close and the potassium channel gates open. K^+ ions rush out of the cell, re-establishing the resting potential.
+30
mV 0
−70
Repolarization begins.
4
RESTORING Na^+/K^+ DISTRIBUTION: As the action potential sweeps along, the original distribution of Na^+ (outside) and K^+ (inside) is restored by the sodium-potassium pumps. Further down the axon, the action potential causes sodium channel gates to open.
+30
mV 0
−70
Repolarization is completed; return to resting potential

Hodgekin Cycle



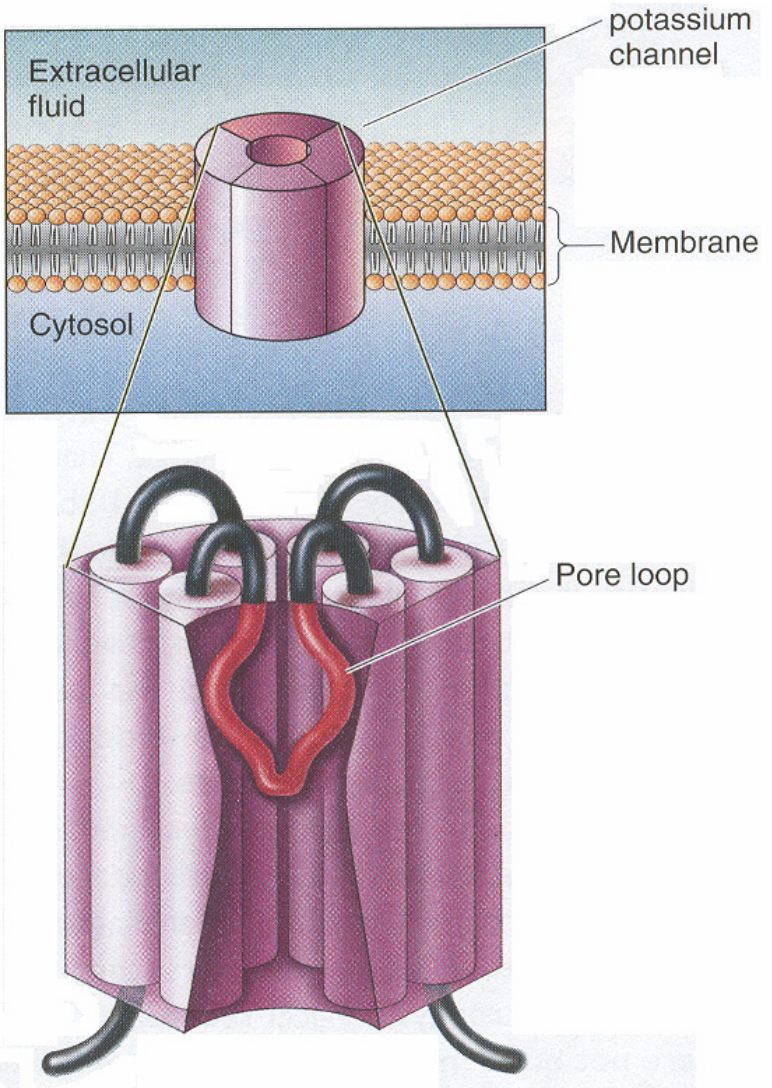
Na통로의 모형

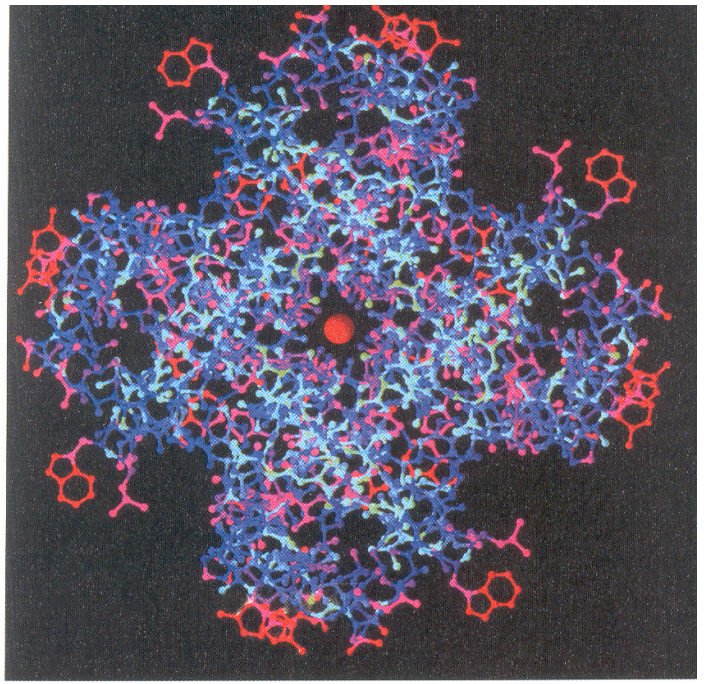




- α-subunit는 4개의 domain, 각 domain은 6개의 TM segments
- S5-S6 사이의 loop 들이 모여 pore 형성, S4에 전압 sensor
- β-subunit는 α-subunit의 안정화.

K통로의 모형

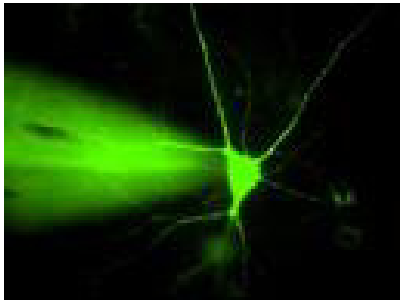

potassium
channel
Extracellular
fluid
Membrane
Cytosol
Pore loop



Patch Clamp technic

Erwin Neher

Bert Sakmann



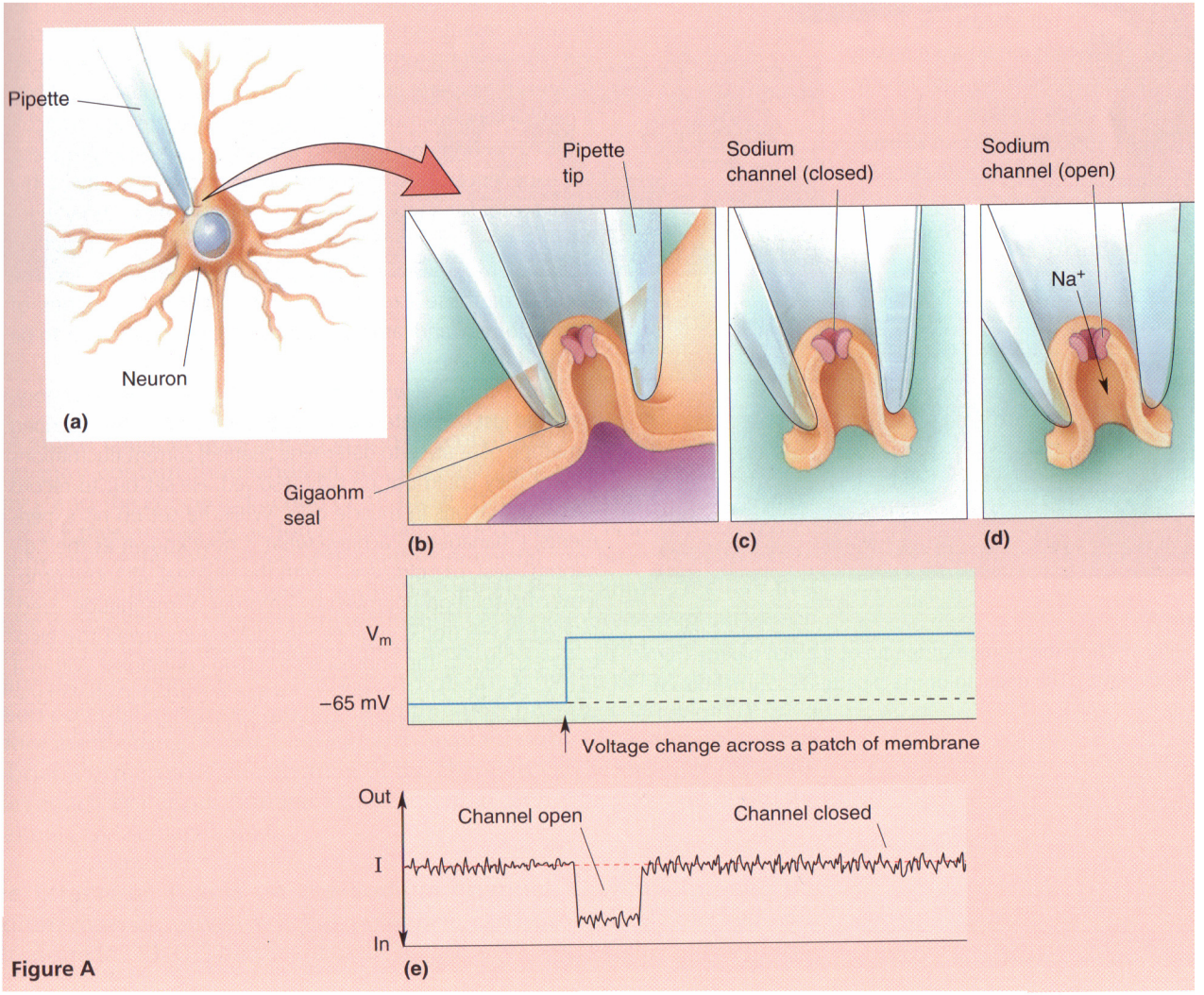
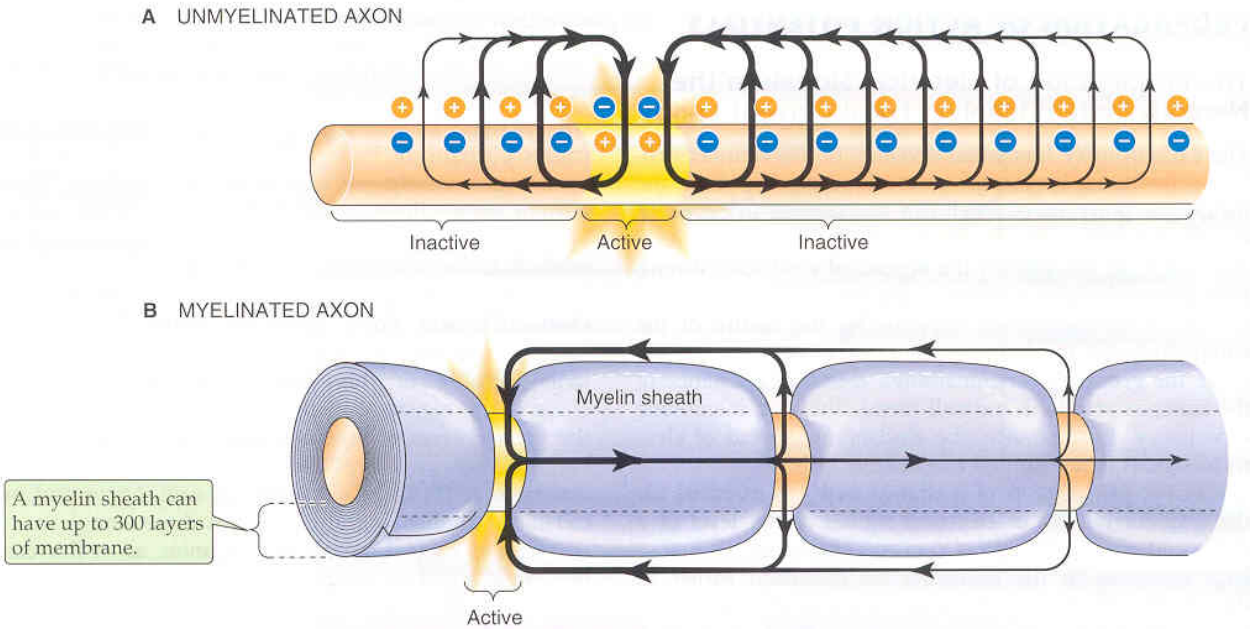

Pipette
Neuron
(a)
Pipette tip
Sodium channel (closed)
Sodium channel (open)
Na+
Gigaohm seal
(b)
(c)
(d)
Vm
–65 mV
Voltage change across a patch of membrane
Out
I
In
Channel open
Channel closed
(e)

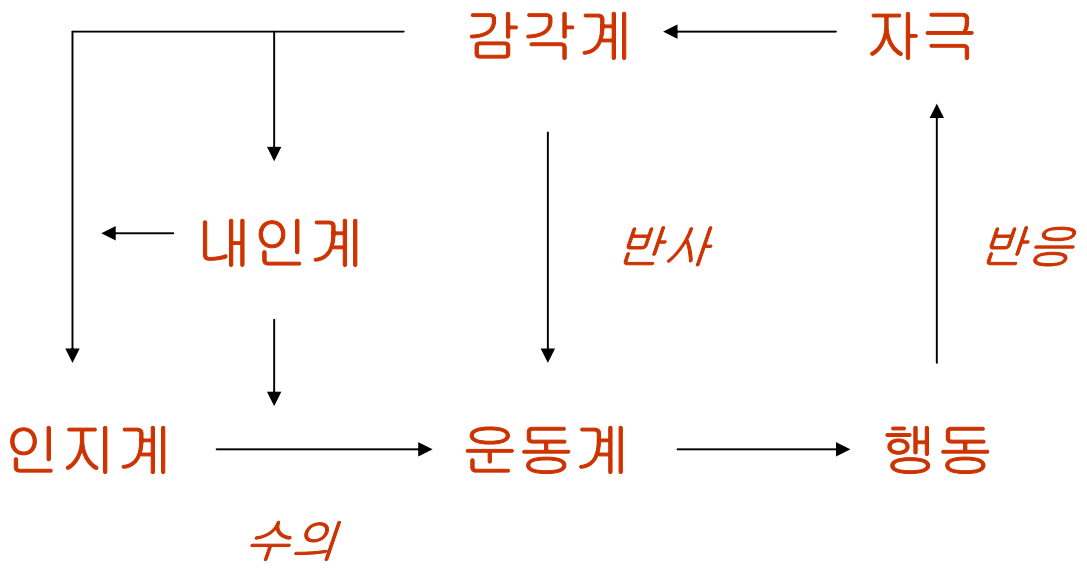
Figure A

활동전압의 전도

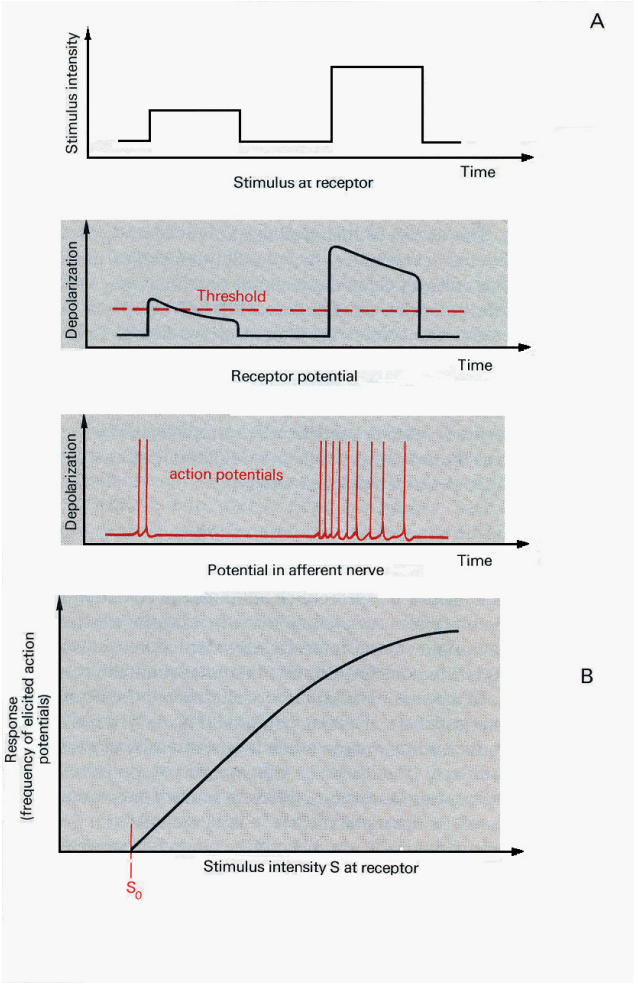
활동전압의 전도


A UNMYELINATED AXON
Inactive
Active
Inactive
B MYELINATED AXON
Myelin sheath
A myelin sheath can have up to 300 layers of membrane.
Active

신경계를 통한 정보의 흐름

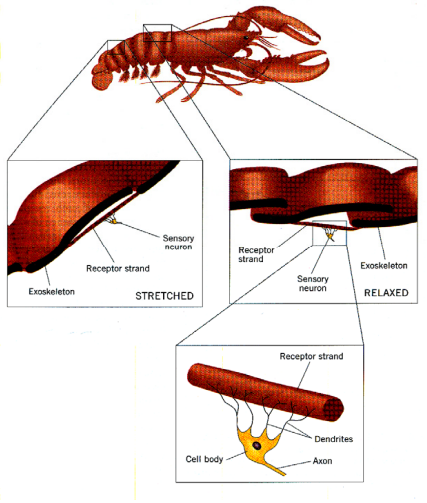


자극의 감수 (transduction)

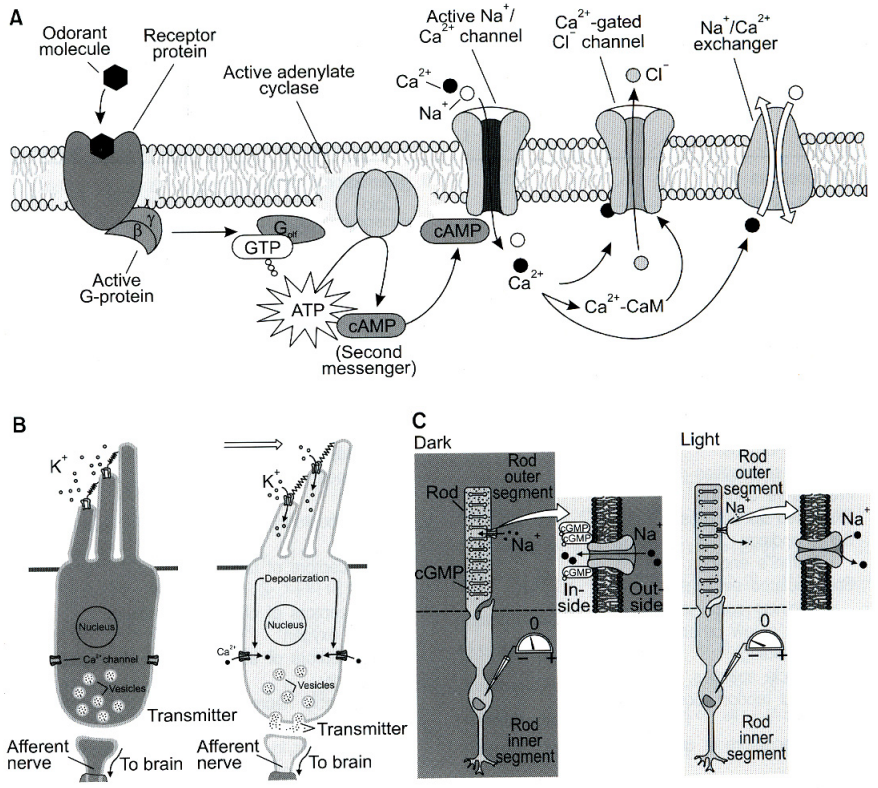


감수기전압

- 탈분극
- 국소적, 점진적 반응
- 적응(adaptation)



감수기전



화학, 빛, 열, 기계적 E

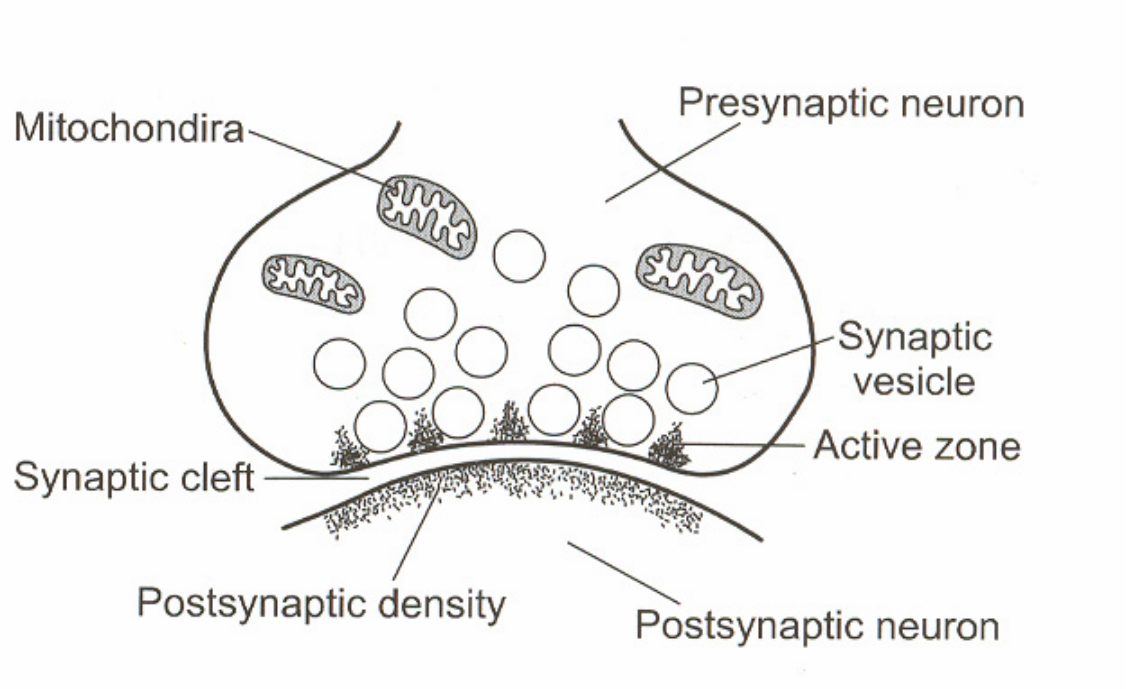
전기 E
(감수기전압)

시냅스 Synapse

시냅스 Synapse

- *신경세포와 신경세포가 만나는 곳.*
- 시냅스 수: 각각의 신경세포는 수천 개 신경세포와 시냅스 형성.
- 구성
  - 시냅스전 신경세포 (presynaptic neuron)
  - 시냅스후 신경세포(postsynaptic neuron)

화학시냅스


Mitochondira
Presynaptic neuron
Synaptic vesicle
Active zone
Synaptic cleft
Postsynaptic density
Postsynaptic neuron

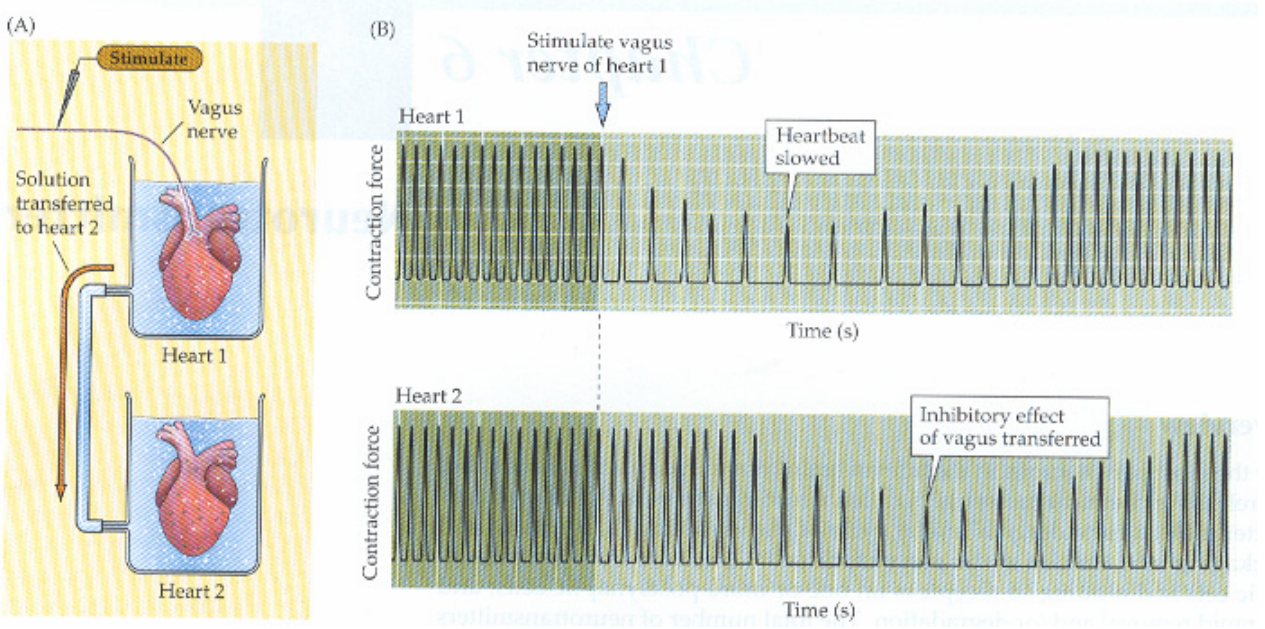


그림 14-5. Otto Loewi의 실험.

Neuroscience, Purves et al, 2001

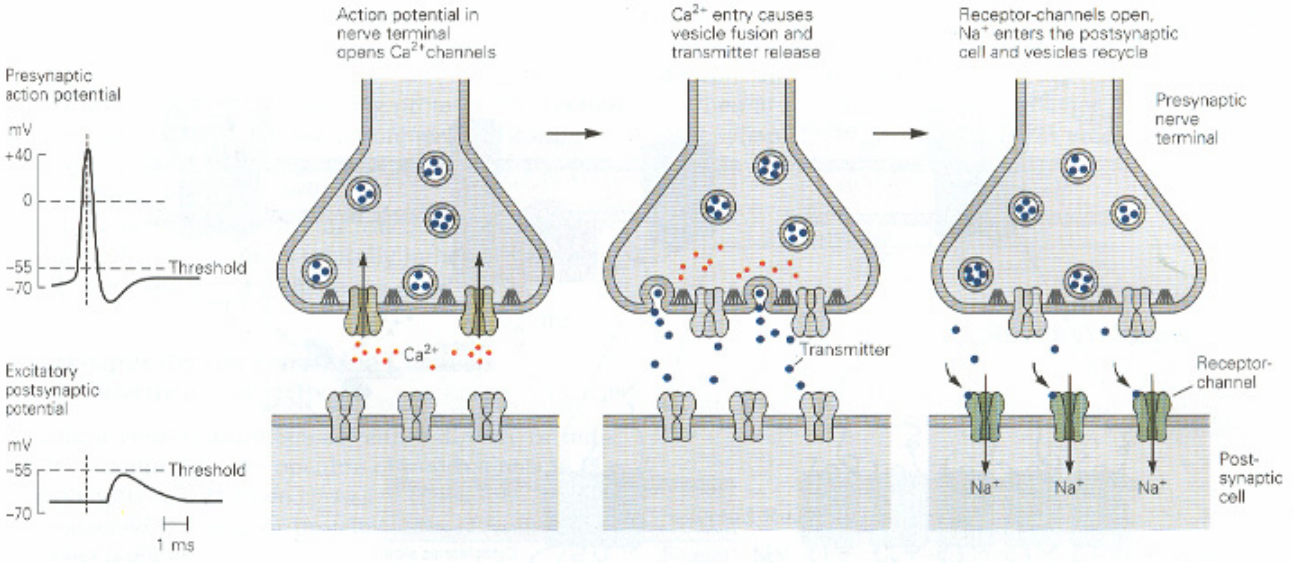
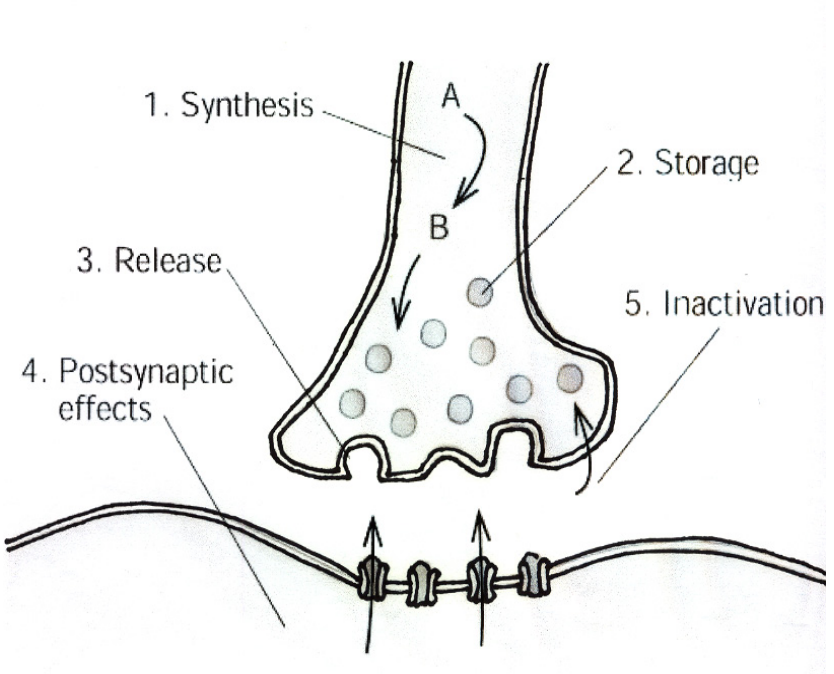


그림 14-10. 화학시냅스에서 시냅스전뉴런의 활동전압이 시냅스후 뉴런으로 전도되는 과정.

Principles of Neuroscience, Kandel et al, 2000

신경전달물질의 판정기준

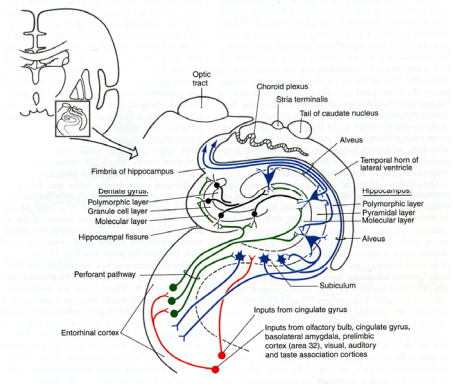


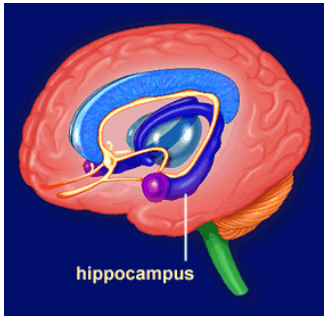
- Agonist
- Antagonist

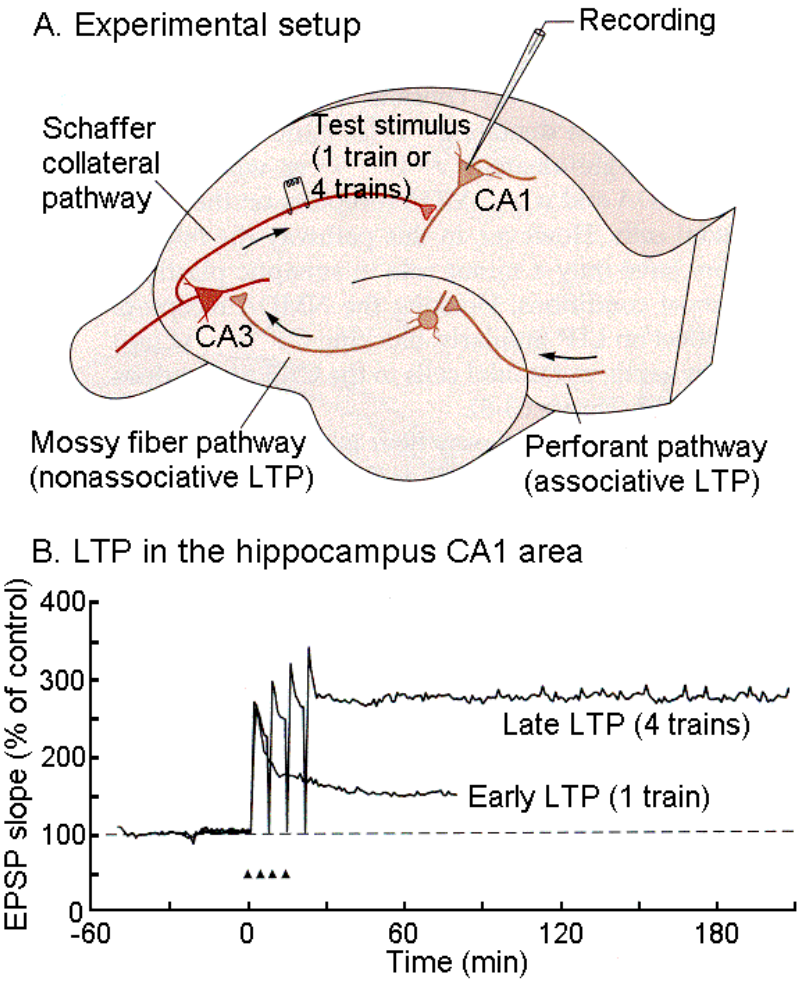
해마 Hippocampus

www.littletoncoin.com

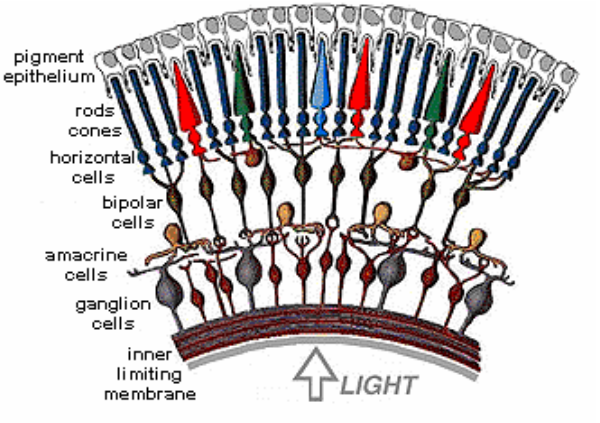
www.waterworxbali.com

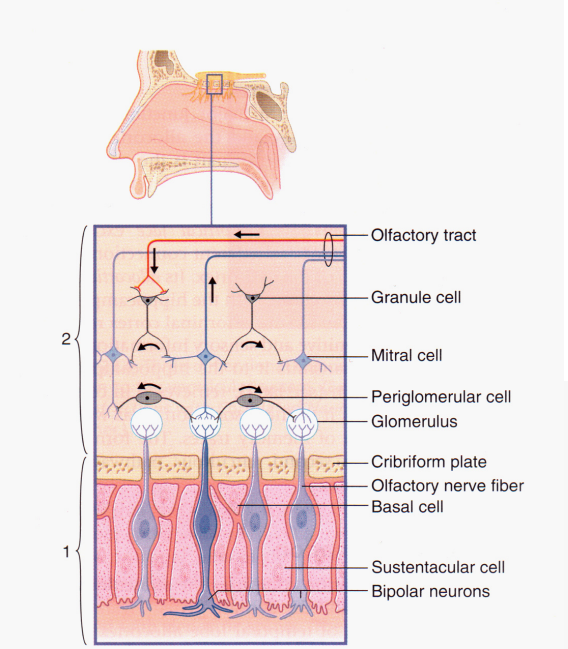


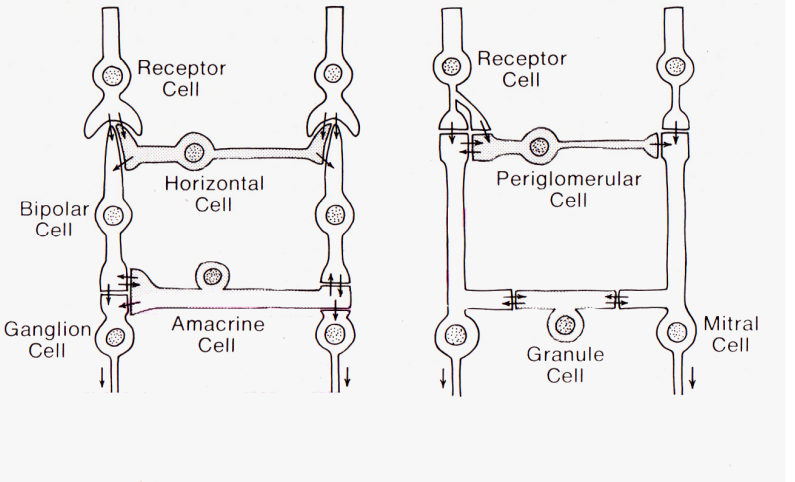



A. Experimental setup
Recording
Schaffer
collateral
pathway
Test stimulus
(1 train or
4 trains)
CA1
CA3
Mossy fiber pathway
(nonassociative LTP)
Perforant pathway
(associative LTP)
B. LTP in the hippocampus CA1 area
EPSP slope (% of control)
400
300
200
100
0
-60
0
60
120
180
Time (min)
Late LTP (4 trains)
Early LTP (1 train)

Retina and Olfactory Neural circuit







Hebbian learning

Fire together,

wire together