Neurophysiology of The Nervous System

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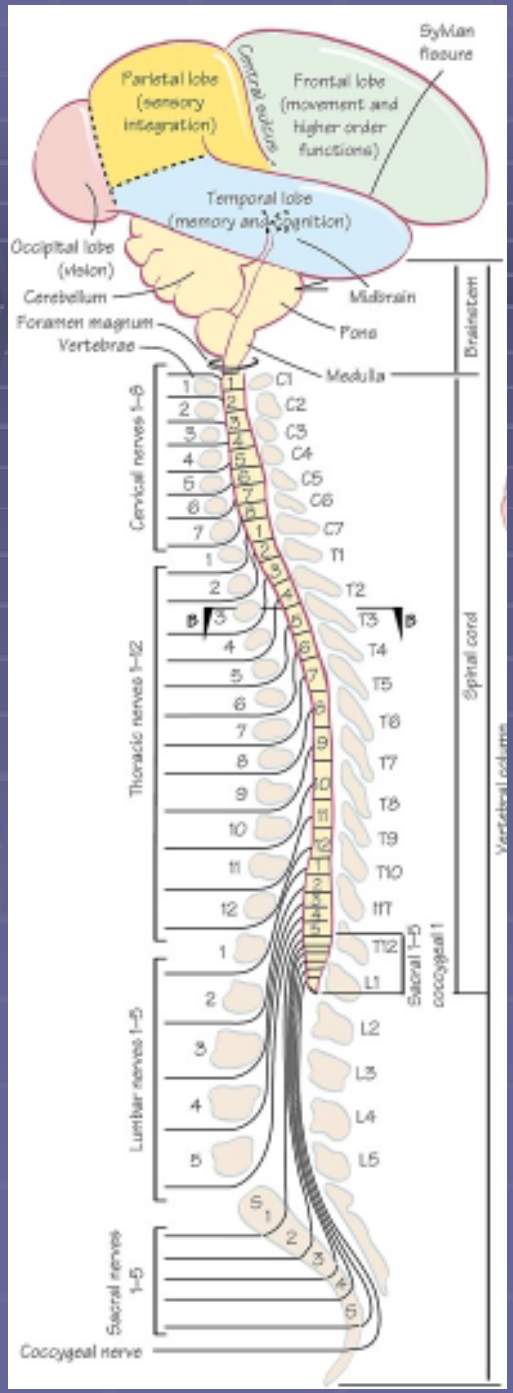
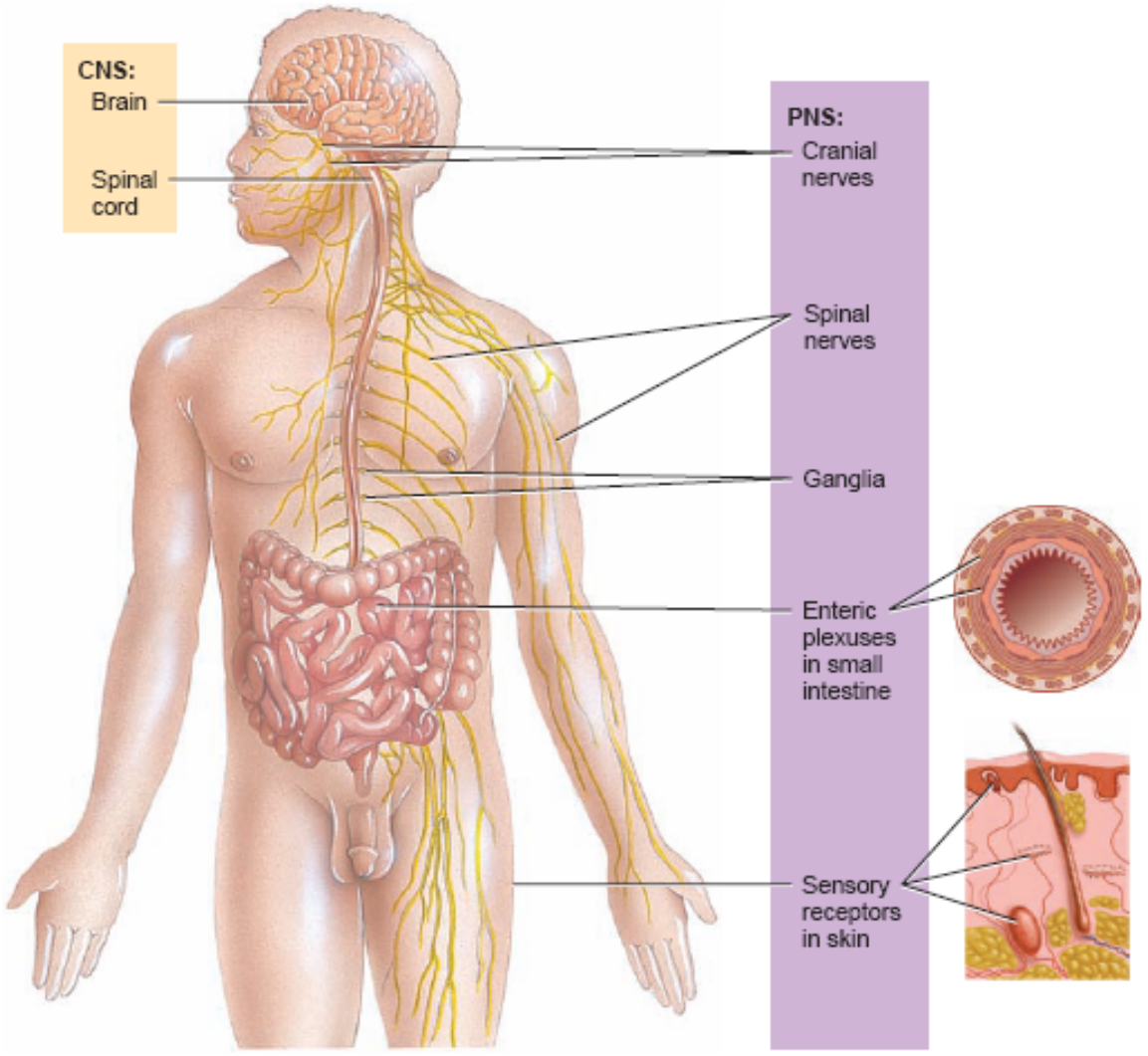

Sylvian fissure
Parietal lobe (sensory integration)
Central sulcus
Frontal lobe (movement and higher order functions)
Temporal lobe (memory and cognition)
Occipital lobe (vision)
Cerebellum
Foramen magnum
Vertebrae
Midbrain
Pons
Medulla
Brainstem
Spinal cord
Vertebral column
Cervical nerves 1–8
Thoracic nerves 1–12
Lumbar nerves 1–5
Sacral nerves 1–5
Coccygeal nerve
Sacral 1–5
Coccygeal 1
C1
C2
C3
C4
C5
C6
C7
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5

Organization of the nervous system



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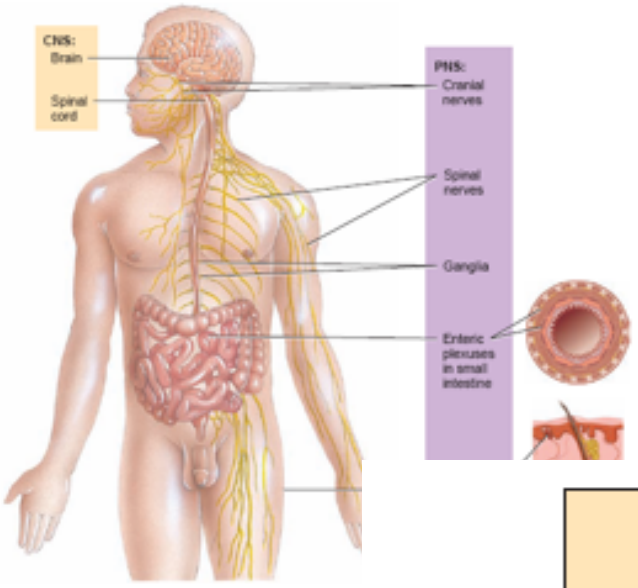
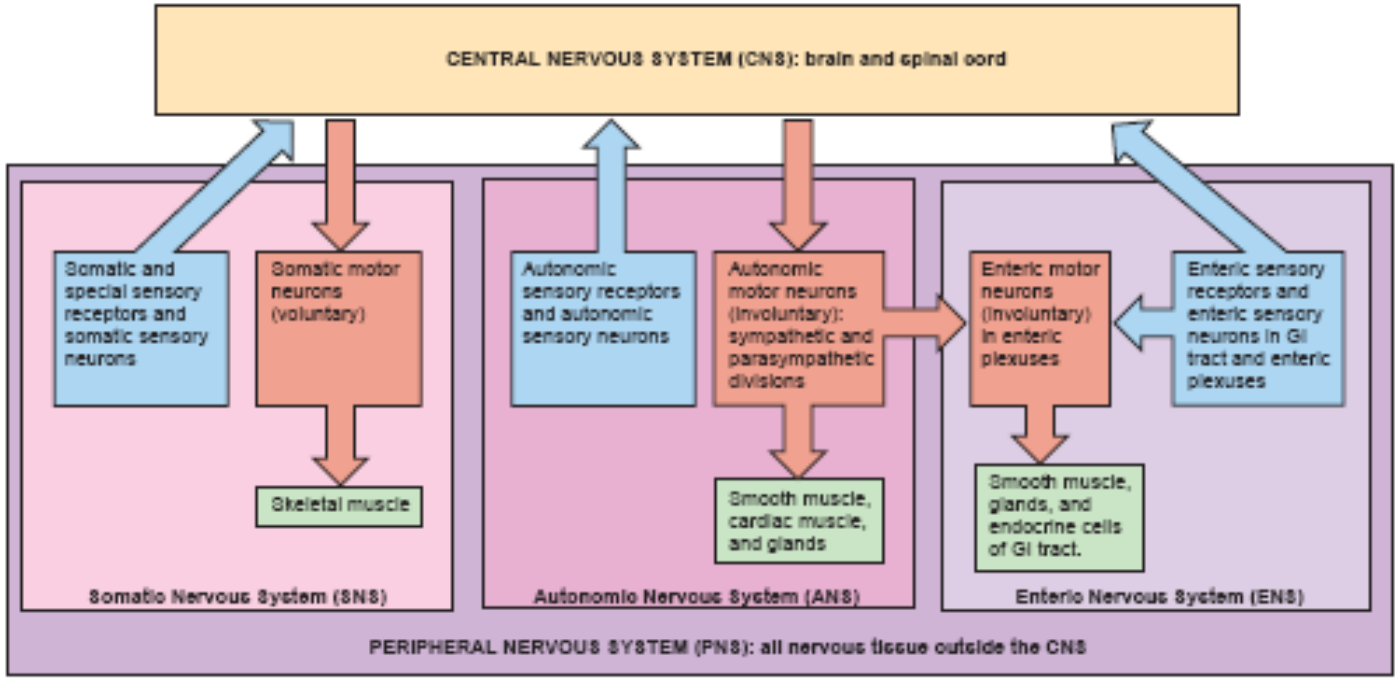
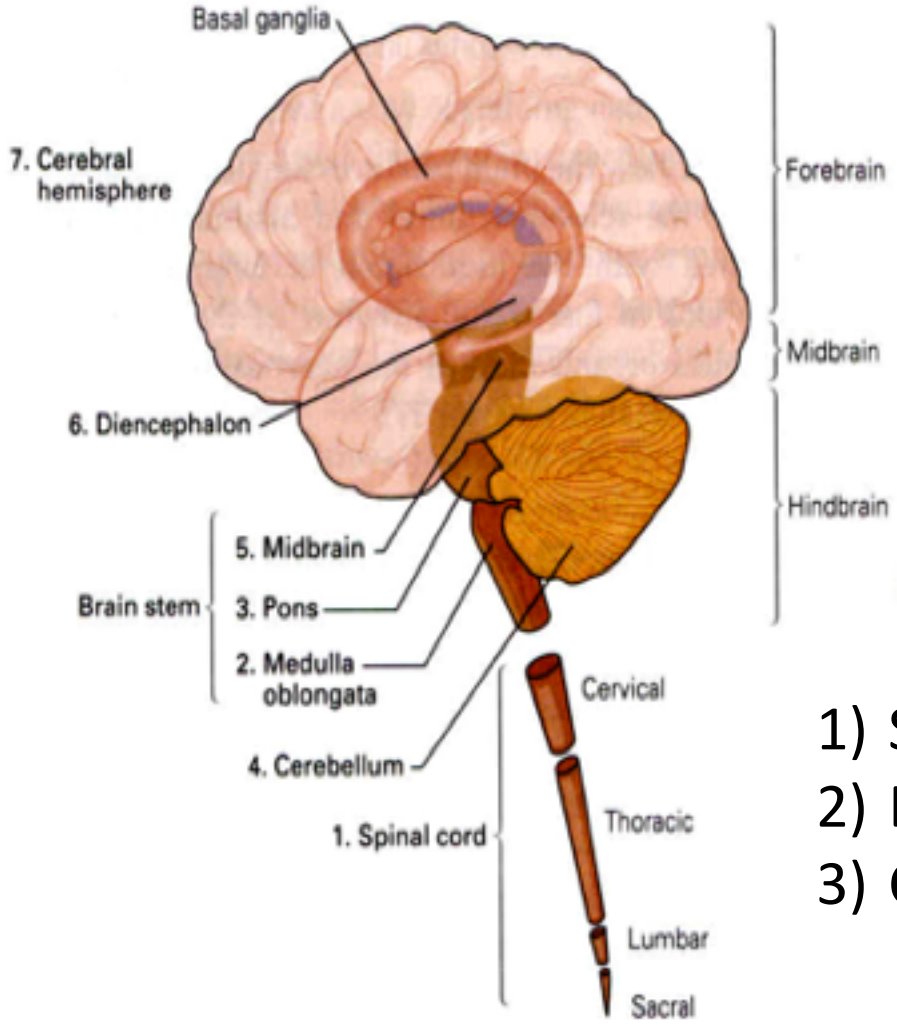




Levels of the CNS



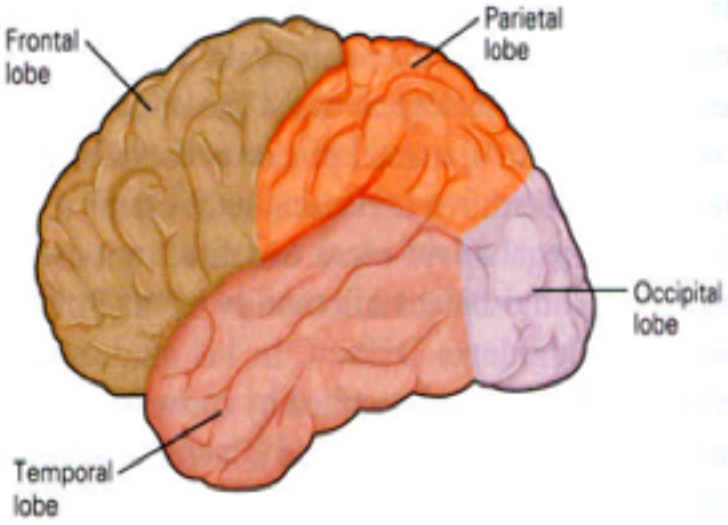


Figure 1-2B The four lobes of the cerebral cortex.

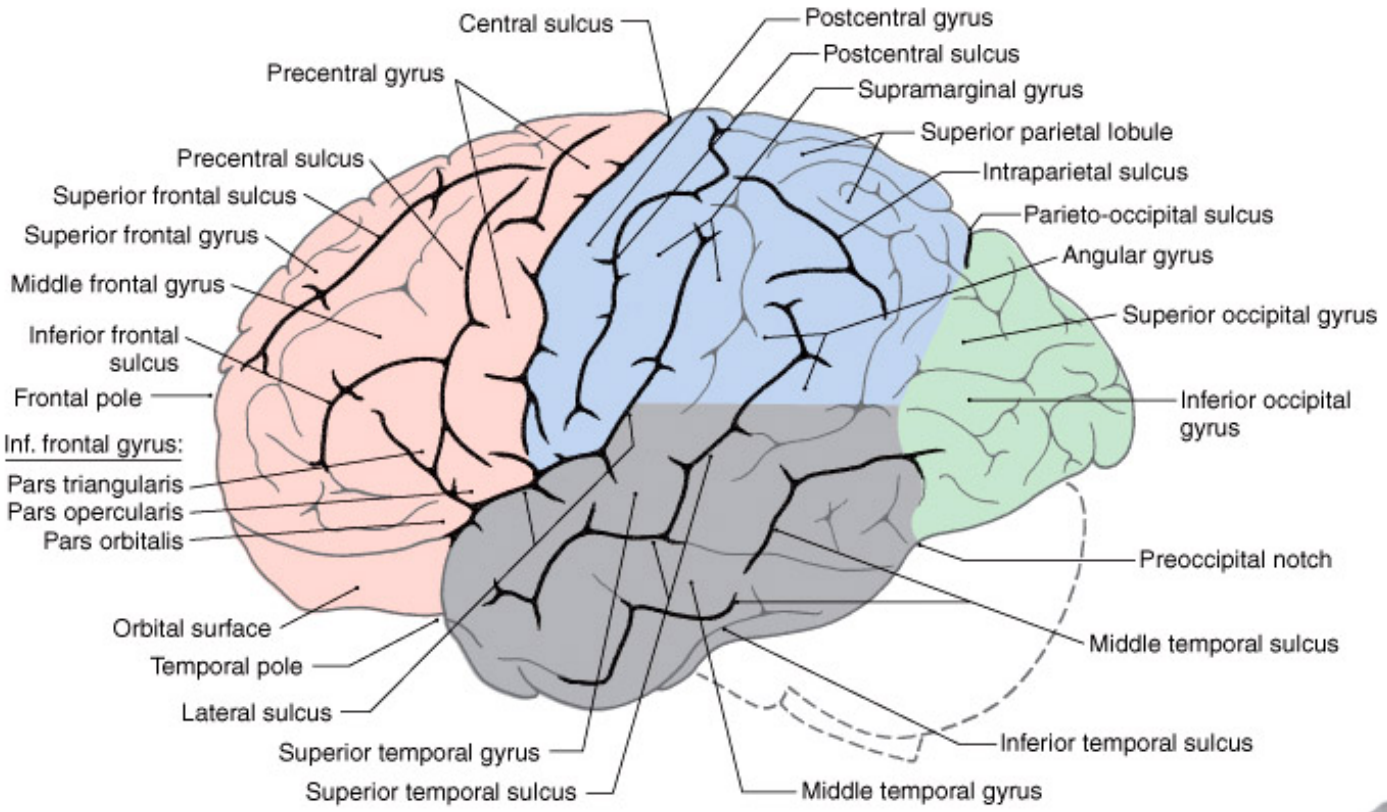
1) Spinal cord
2) Brain stem and sub cortical
3) Cerebral cortex

3 Major Levels of CNS Function

- The spinal cord level.
  - more than just a conduit for signals from periphery of body to brain and vice versa.
  - cord contains:
    - walking circuits.
    - reflexes circuits.

The brain stem and subcortical

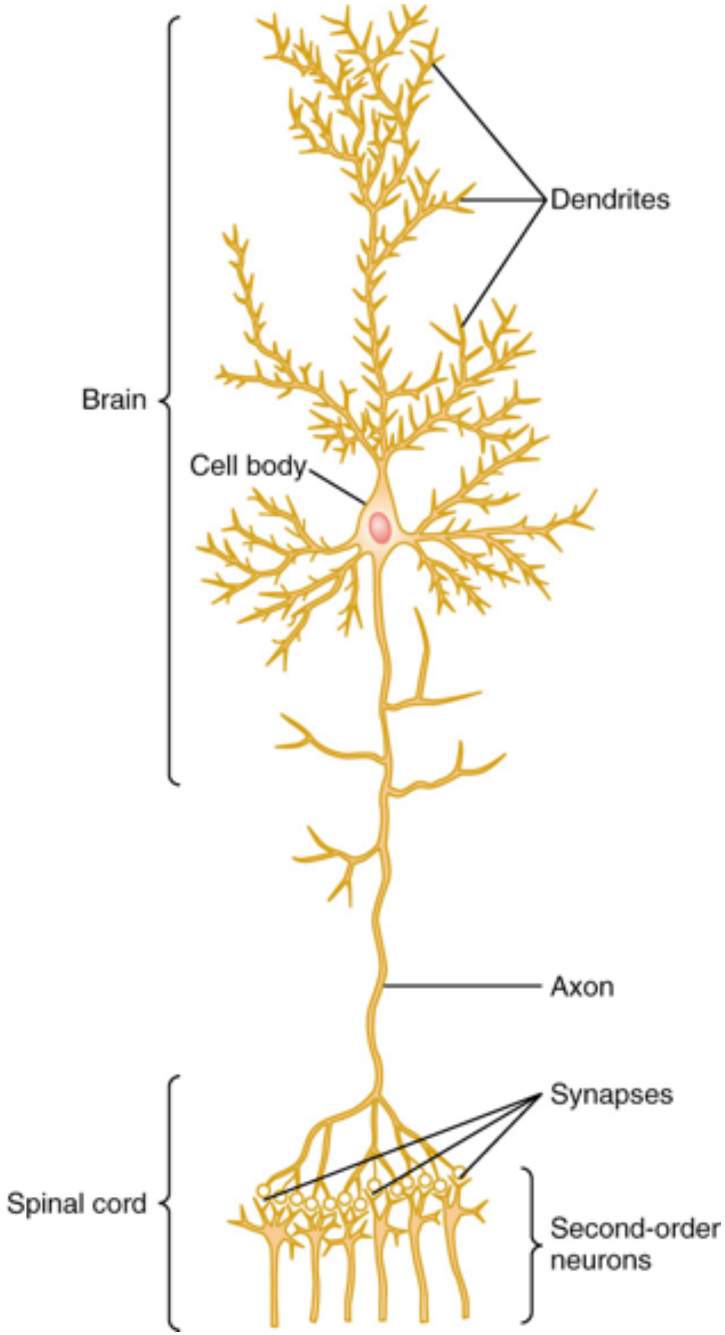
- Contains:
  - medulla, pons, mesencephalon, hypothalamus, thalamus, cerebellum and basal ganglia.
- Controls subconscious body activities:
  - arterial pressure, respiration, equilibrium, feeding reflexes, emotional patterns.


Central sulcus
Postcentral gyrus
Postcentral sulcus
Precentral gyrus
Supramarginal gyrus
Superior parietal lobule
Precentral sulcus
Intraparietal sulcus
Superior frontal sulcus
Parieto-occipital sulcus
Superior frontal gyrus
Angular gyrus
Middle frontal gyrus
Superior occipital gyrus
Inferior frontal sulcus
Frontal pole
Inferior occipital gyrus
Inf. frontal gyrus:
Pars triangularis
Pars opercularis
Pars orbitalis
Preoccipital notch
Middle temporal sulcus
Orbital surface
Temporal pole
Lateral sulcus
Inferior temporal sulcus
Superior temporal gyrus
Superior temporal sulcus
Middle temporal gyrus

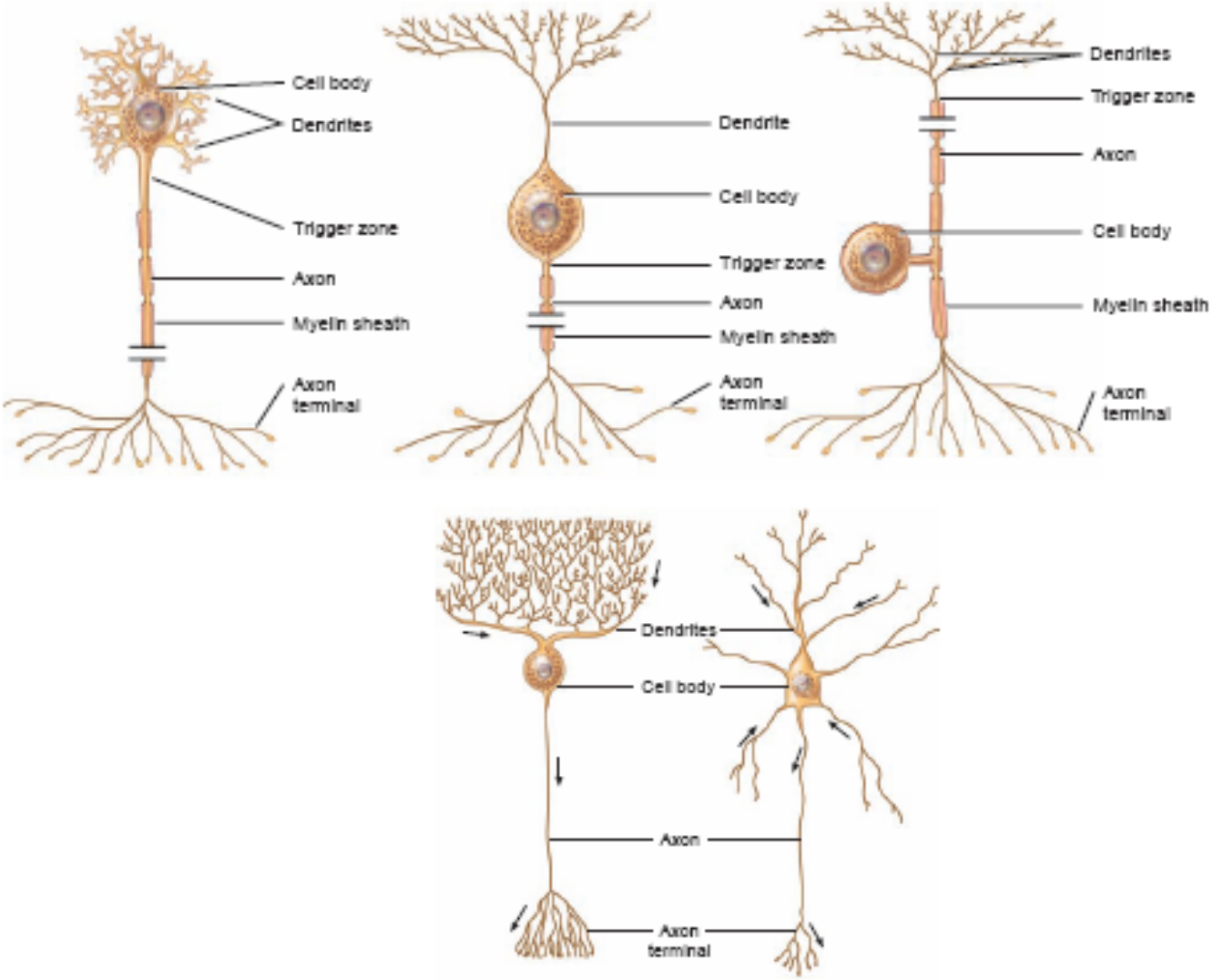
The Higher Brain or Cortical Level

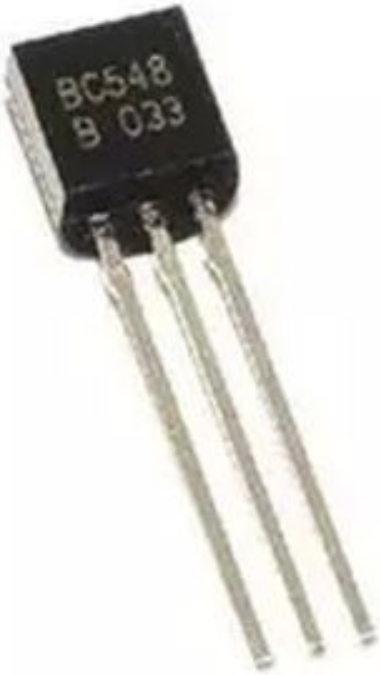
- Higher order functions : language, thoughts and personality
- Large memory storehouse.
- Each portion of the nervous system performs specific functions, but it is the cortex that opens the world up for one's mind.

Neuron Structure

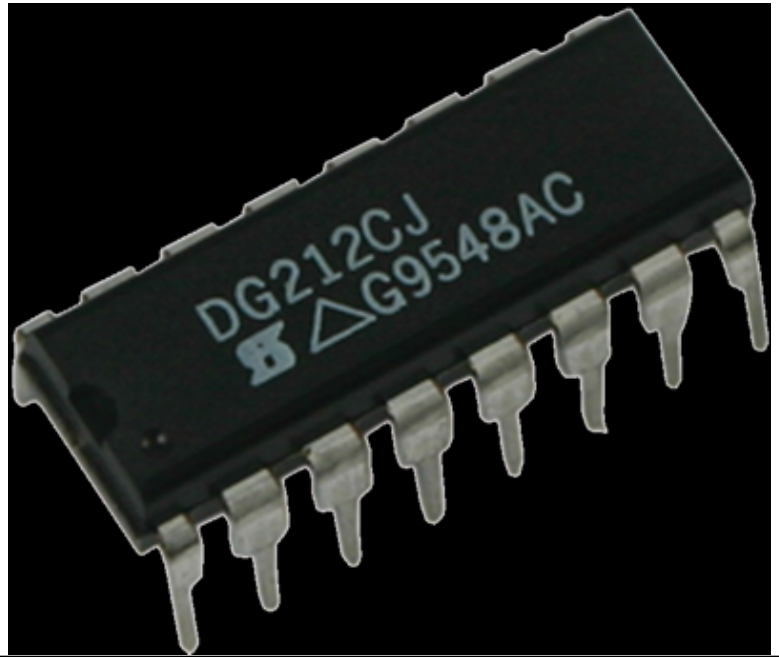


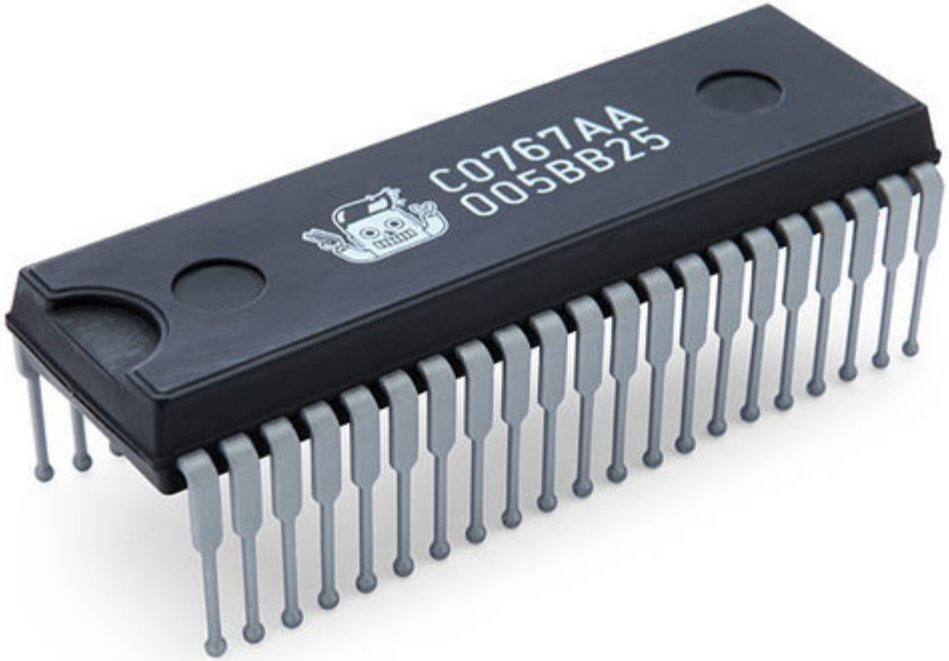
Types of neurons



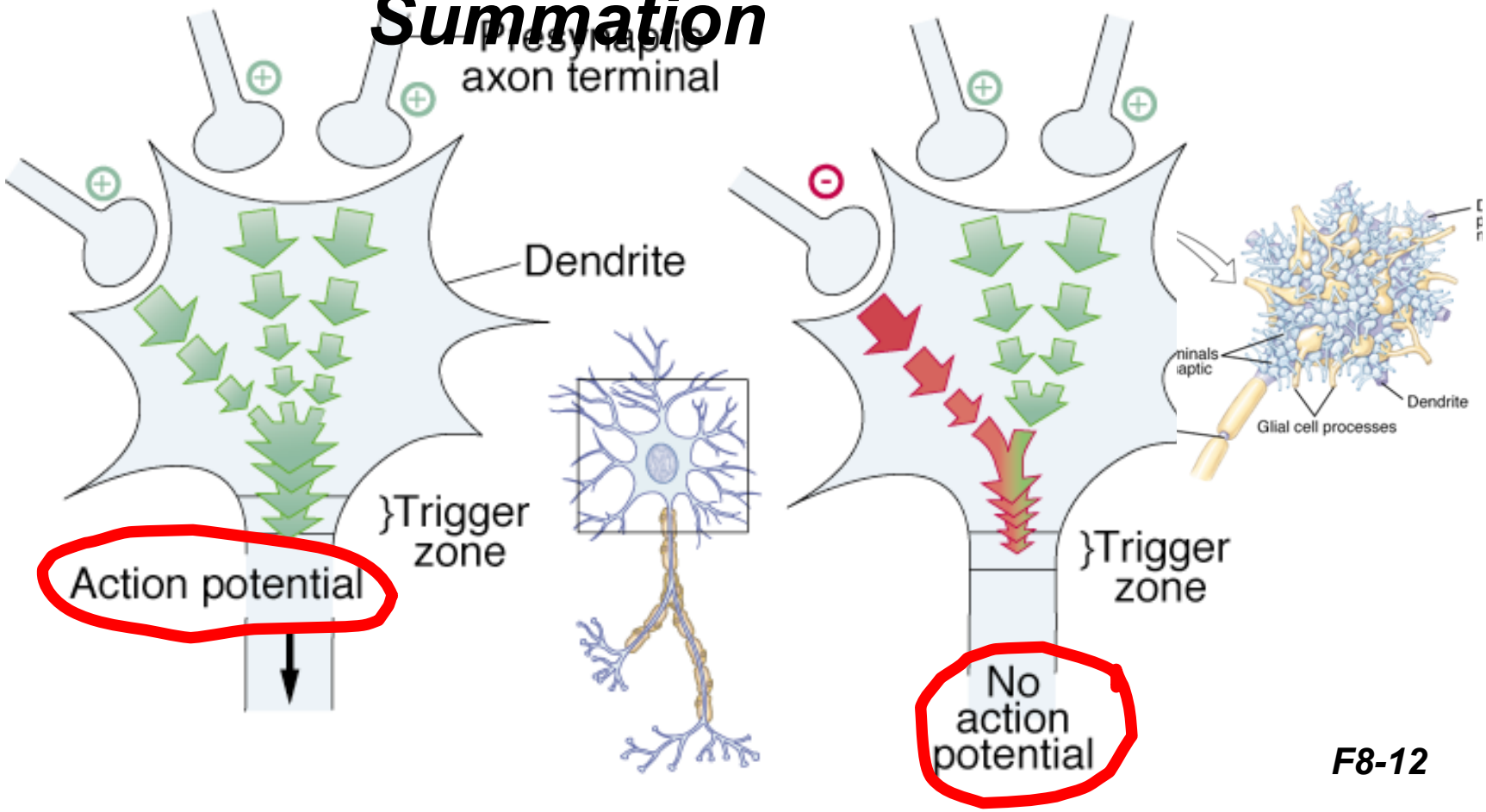

BC548
B 033


W9901 9828
MALAYSIA


DG212CJ
G9548AC

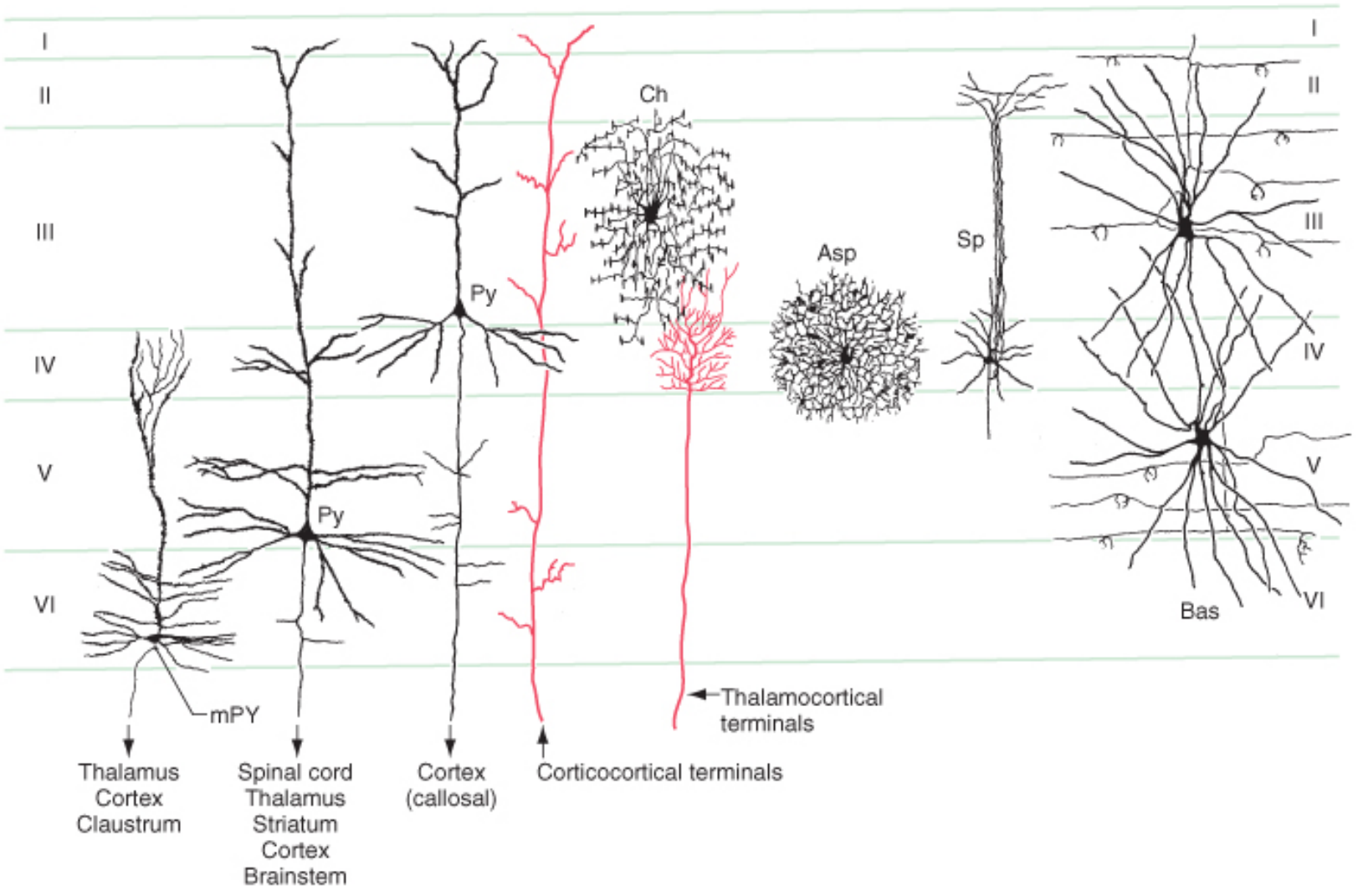

C0767AA
005BB25

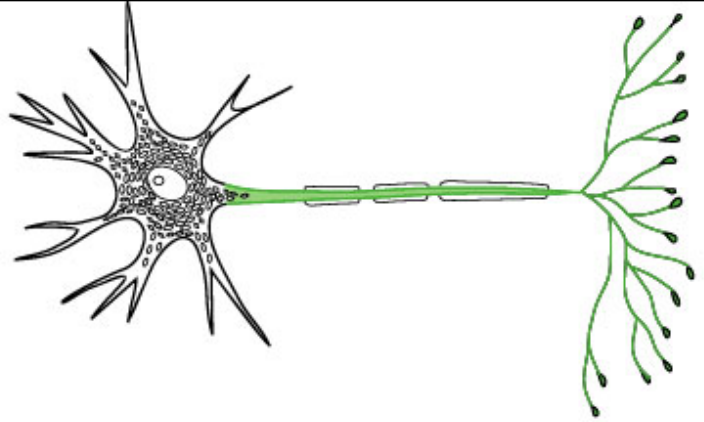
Spatial Summation

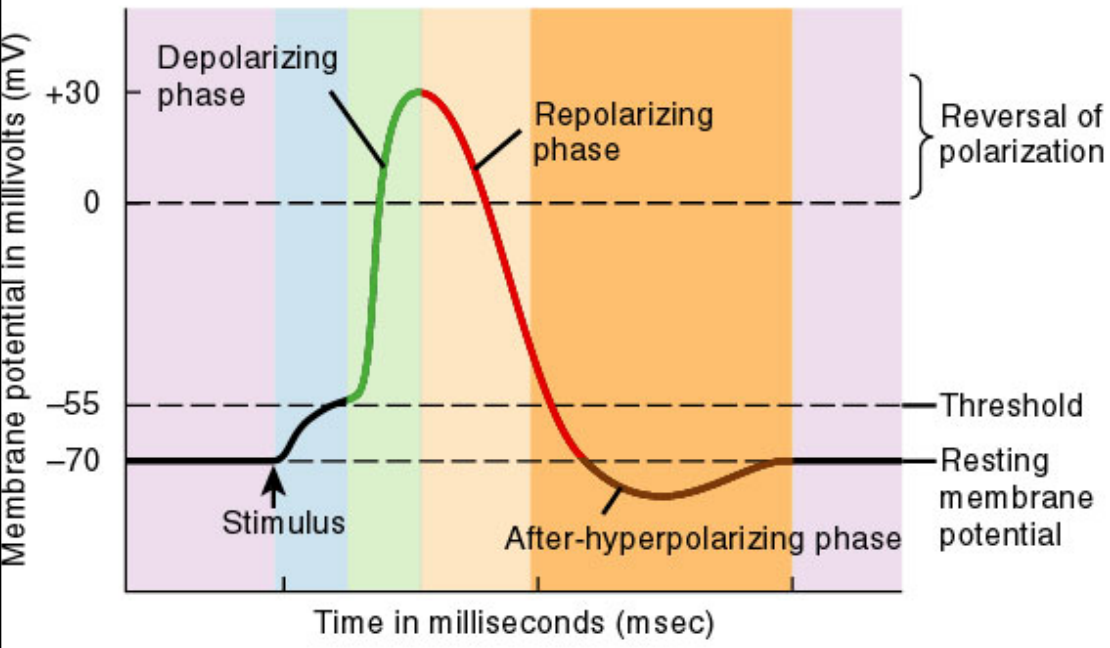


F8-12

- *A neuron may receive greater than 10, 000 inputs from presynaptic neurons.*
- *The initiation of an action potential from several simultaneous subthreshold graded potentials, originating from different locations, is known as spatial summation.*


I
II
III
IV
V
VI
Py
Py
Ch
Asp
Sp
mPY
Thalamocortical terminals
Corticocortical terminals
Thalamus
Cortex
Claustrum
Spinal cord
Thalamus
Striatum
Cortex
Brainstem
Cortex
(callosal)
Bas





Key:

- Resting membrane potential: Voltage-gated Na^+ channels are in the resting state and voltage-gated K^+ channels are closed
- Stimulus causes depolarization to threshold
- Voltage-gated Na^+ channel activation gates are open
- Voltage-gated K^+ channels are open; Na^+ channels are inactivating

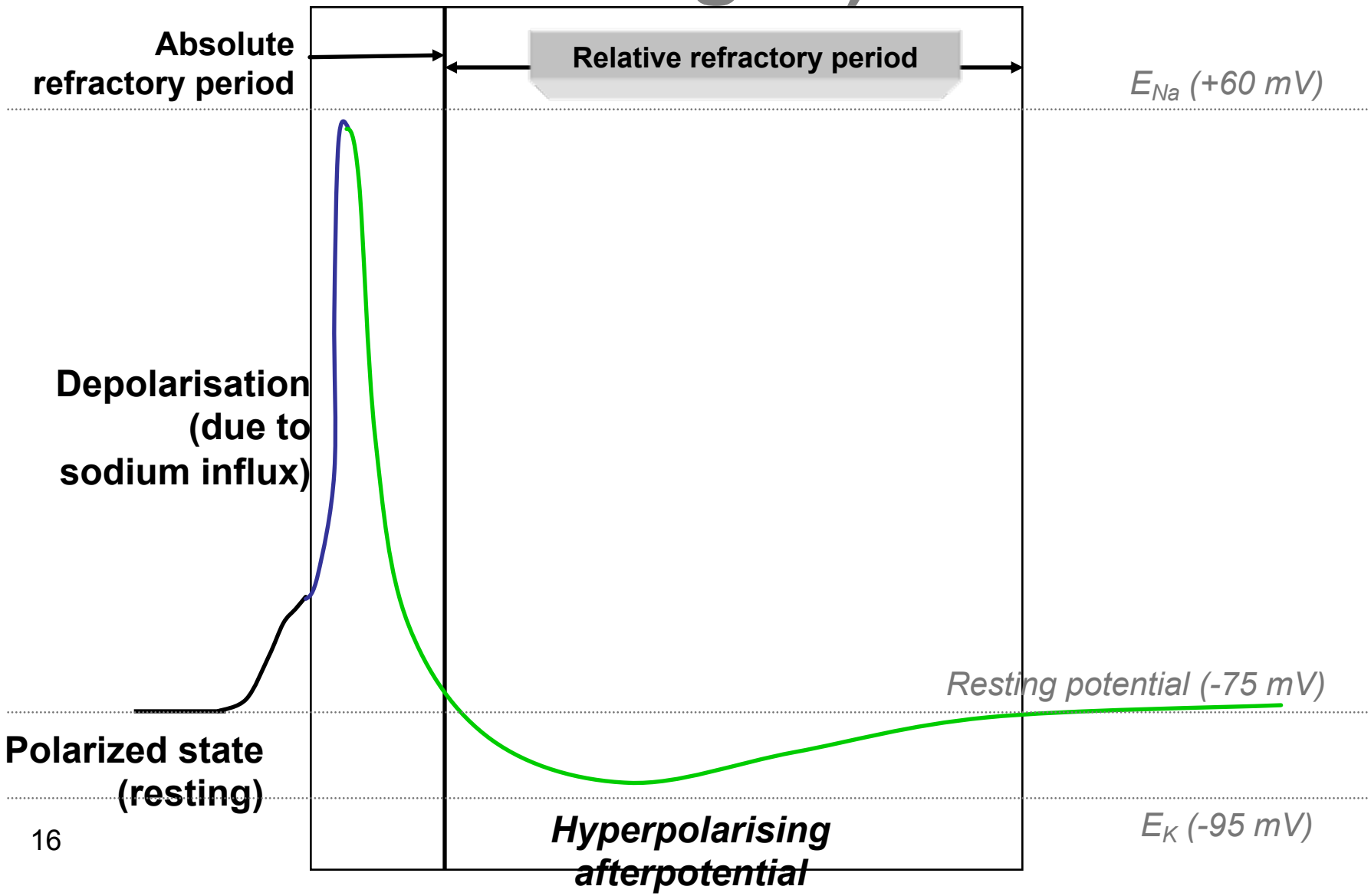
  } Absolute refractory period

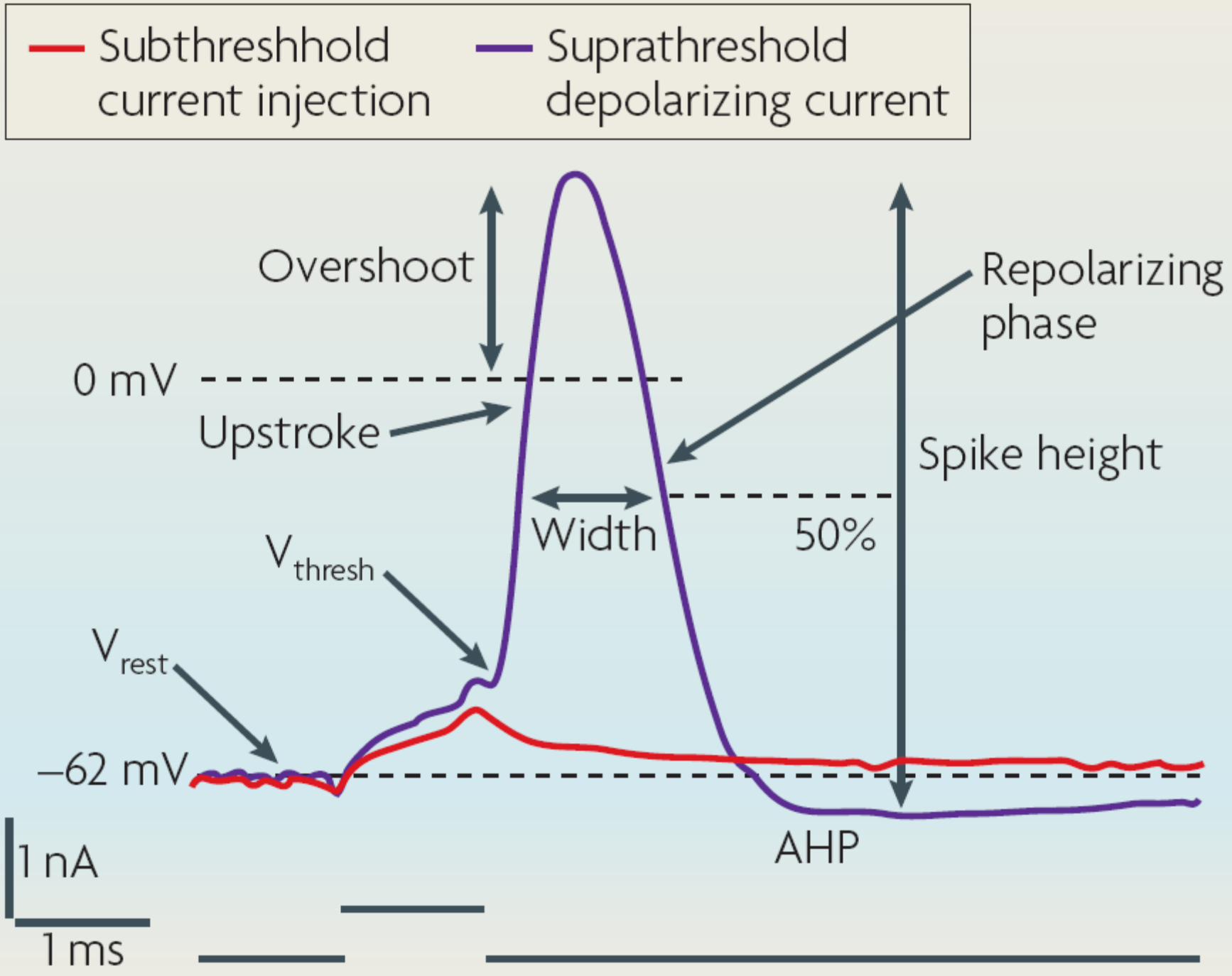
- Voltage-gated K^+ channels are still open; Na^+ channels are in the resting state

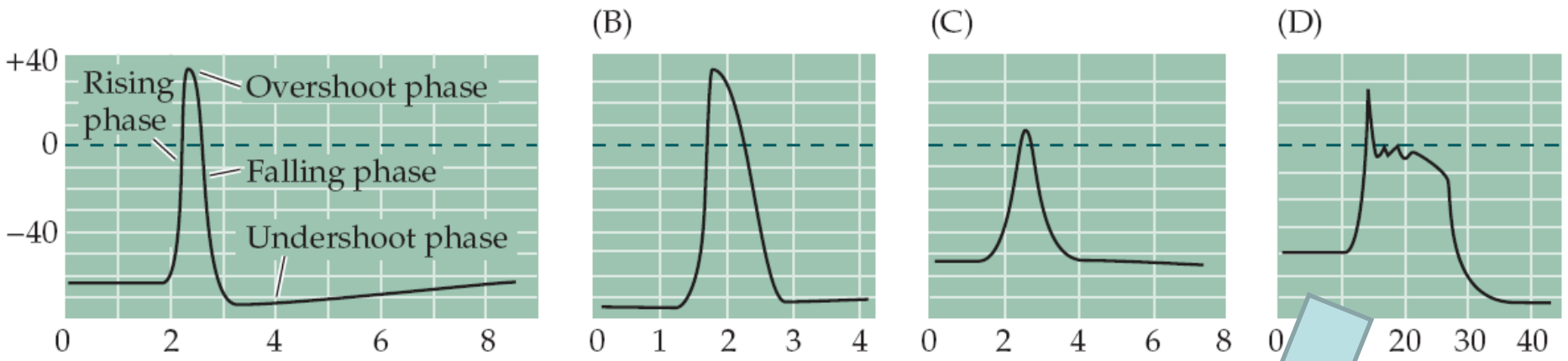
  } Relative refractory period

12.11

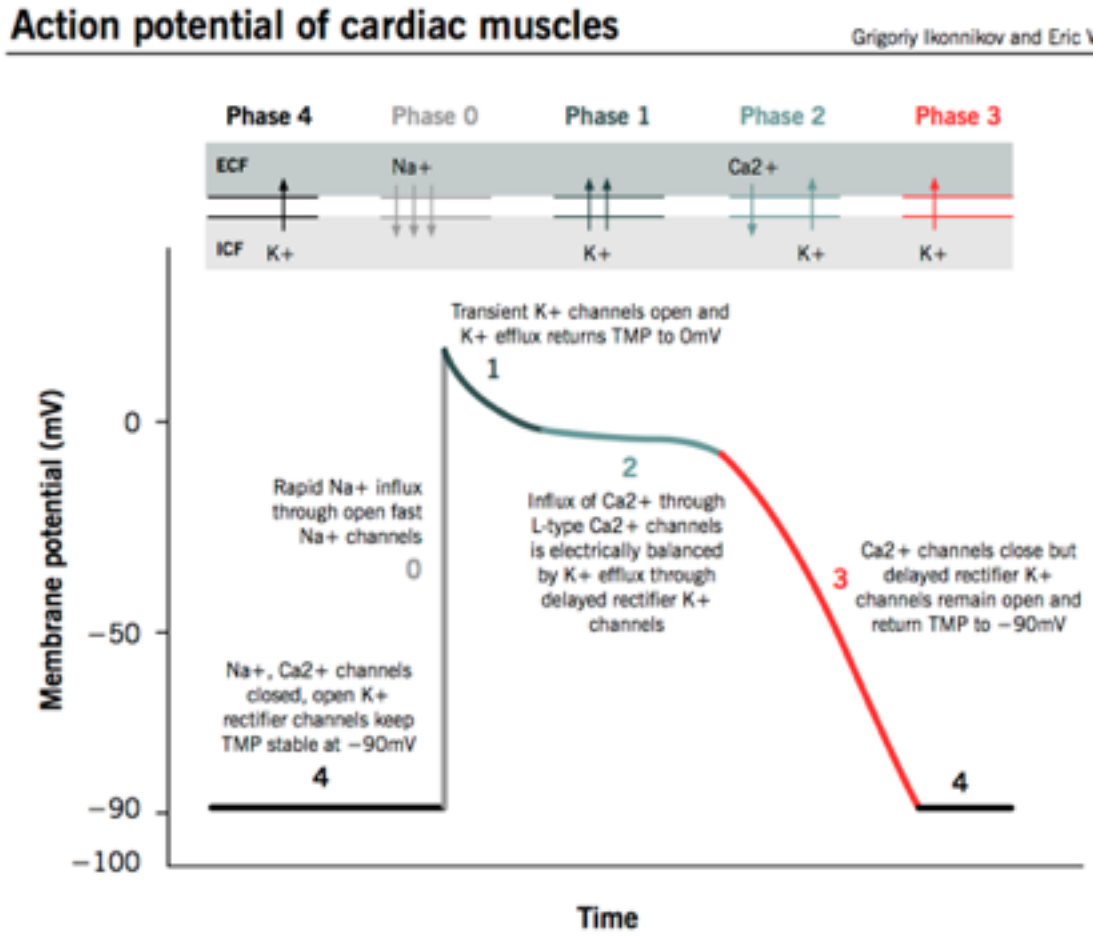
The Action Potential (excitability changes)




Subthreshhold current injection
Suprathreshold depolarizing current
Overshoot
Repolarizing phase
0 mV
Upstroke
Spike height
Width
50%
V_{thresh}
V_{rest}
–62 mV
AHP
1 nA
1 ms



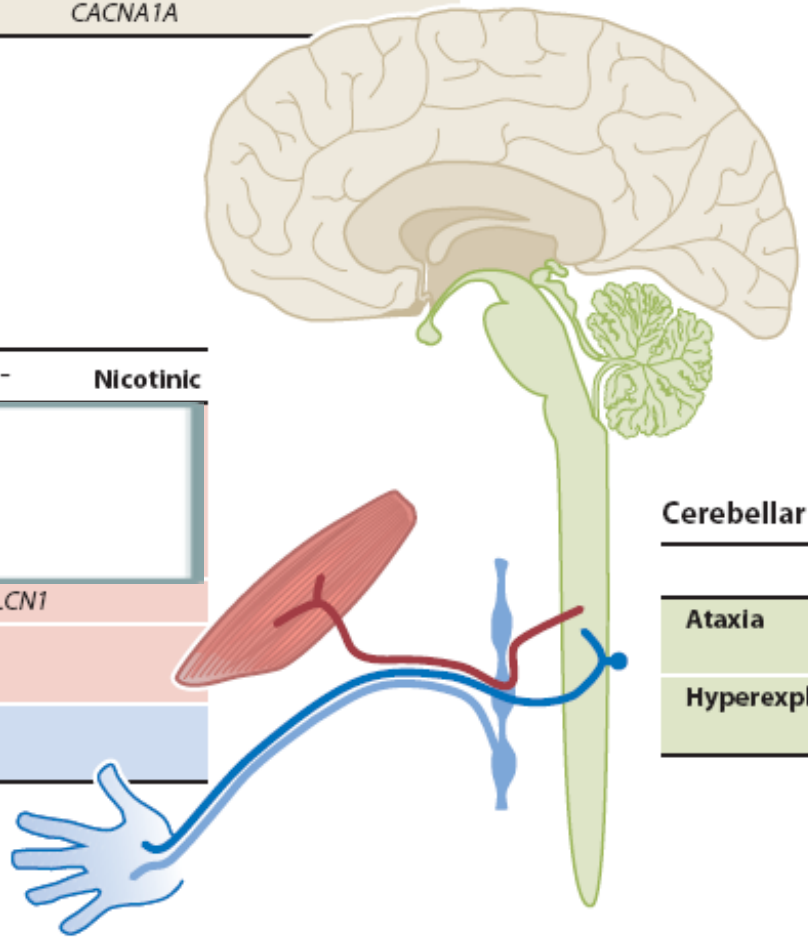
neuron from the inferior olive



Channelopathies

Epilepsy and migraine

	Na^+	K^+	Ca^{2+}
Epilepsy	*SCN1A* *SCN1B* *SCN2A*	*KCNQ2* *KCNQ3* *KCNMA1*	*CACNA1H*
Migraine	*SCN1A*		*CACNA1A*



Neuromuscular disorders

	Na^+	K^+	Ca^{2+}	Cl^-	Nicotinic
Myotonia	*SCN4A*			*CLCN1*	
Periodic paralysis	*SCN4A*	*KCNJ2*	*CACNA1S*		
Pain Erythema	*SCN9A*				

Cerebellar ataxia and excessive startle

	K^+	Ca^{2+}
Ataxia	*KCNA1* *KCNC3*	*CACNA1A*
Hyperexplexia		

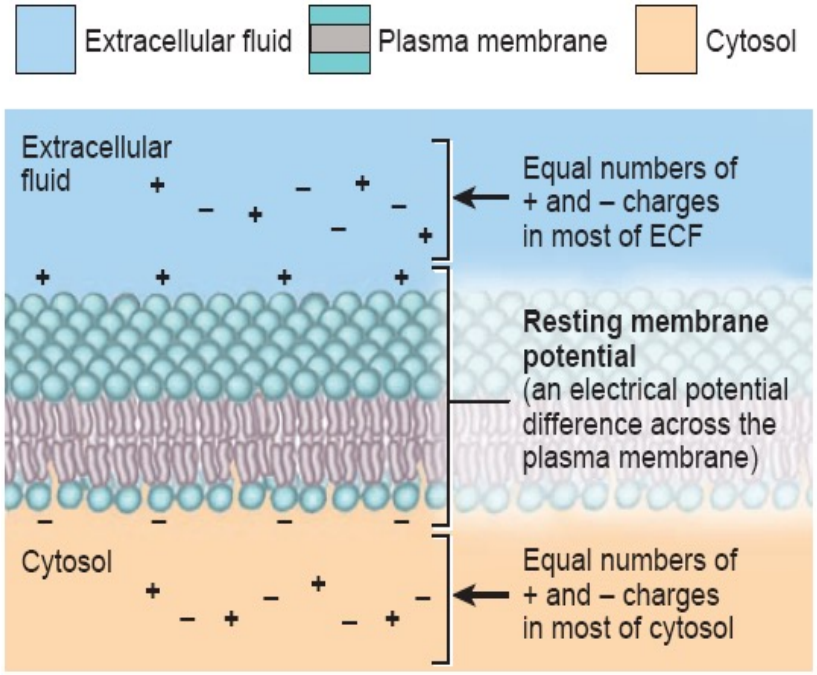
Ataxia is typically defined as the presence of abnormal, uncoordinated movements

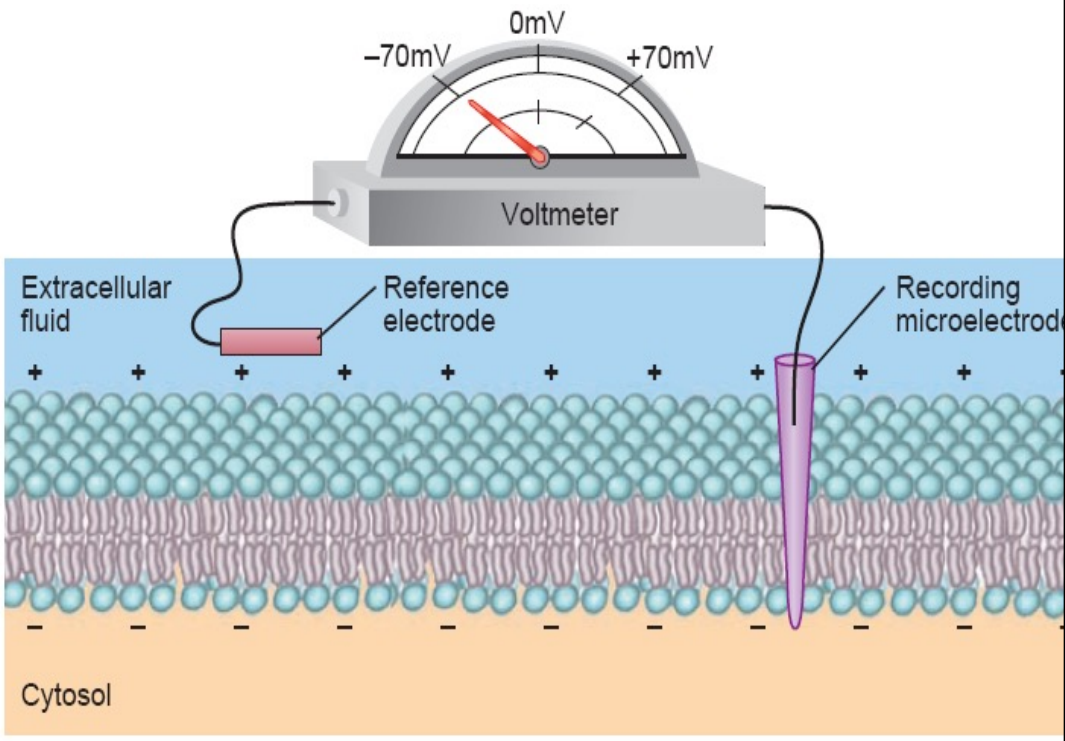
- Pages 84 & 85 in

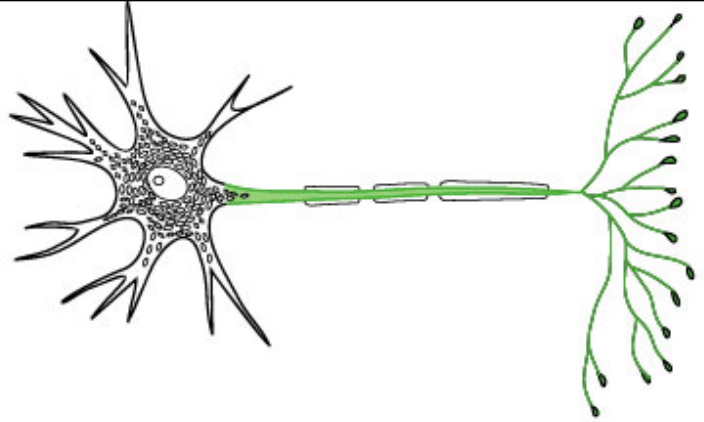
  Neuroscience 3rd edition by Dale *Purves*

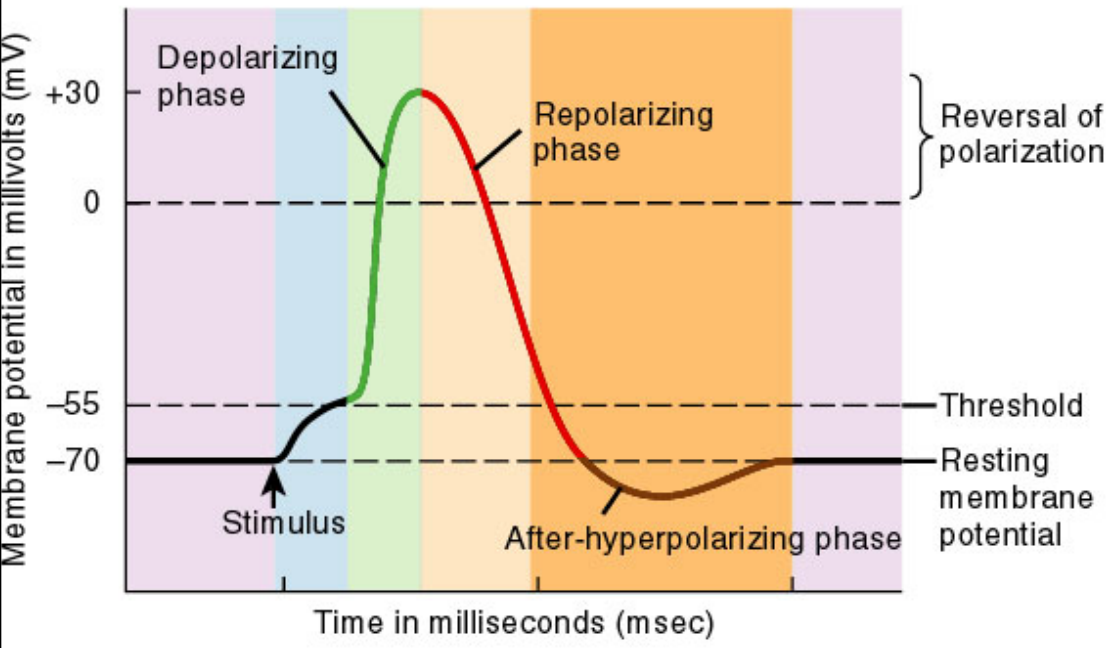
Ion Channel Neurotoxins

Resting Membrane Potential









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Resting Membrane Potential & Goldman Equation

$$V_m = \frac{RT}{F} \log \frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{cl}[Cl^-]_o}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{cl}[Cl^-]_i}$$

- P = permeability
- at rest: P_K: P_{Na}: P_{Cl} = 1.0 : 0.04 : 0.45 –
- Net potential movement for all ions
- known V_m:Can predict direction of movement of any ion ~

Effect of K Ions on the RMP

Effect of K Ions on the RMP

- hyperkalemia :
- weakness, ascending paralysis,
- If untreated cardiac arrhythmias
- Hypokalemia : serum K+ <3.5 mEq/L

Myopathies (**Myotonia**)

weakness, fatigue, paralysis

Effect of K Ions on the RMP

- hyperkalemia : serum K+ >5 mEq/L, moderate (6 to 7 mEq/L) and severe (>7 mEq/L)

- Hypokalemia :

Weakness , fatigue, motor paralysis

Myopathies (**Myotonia**)

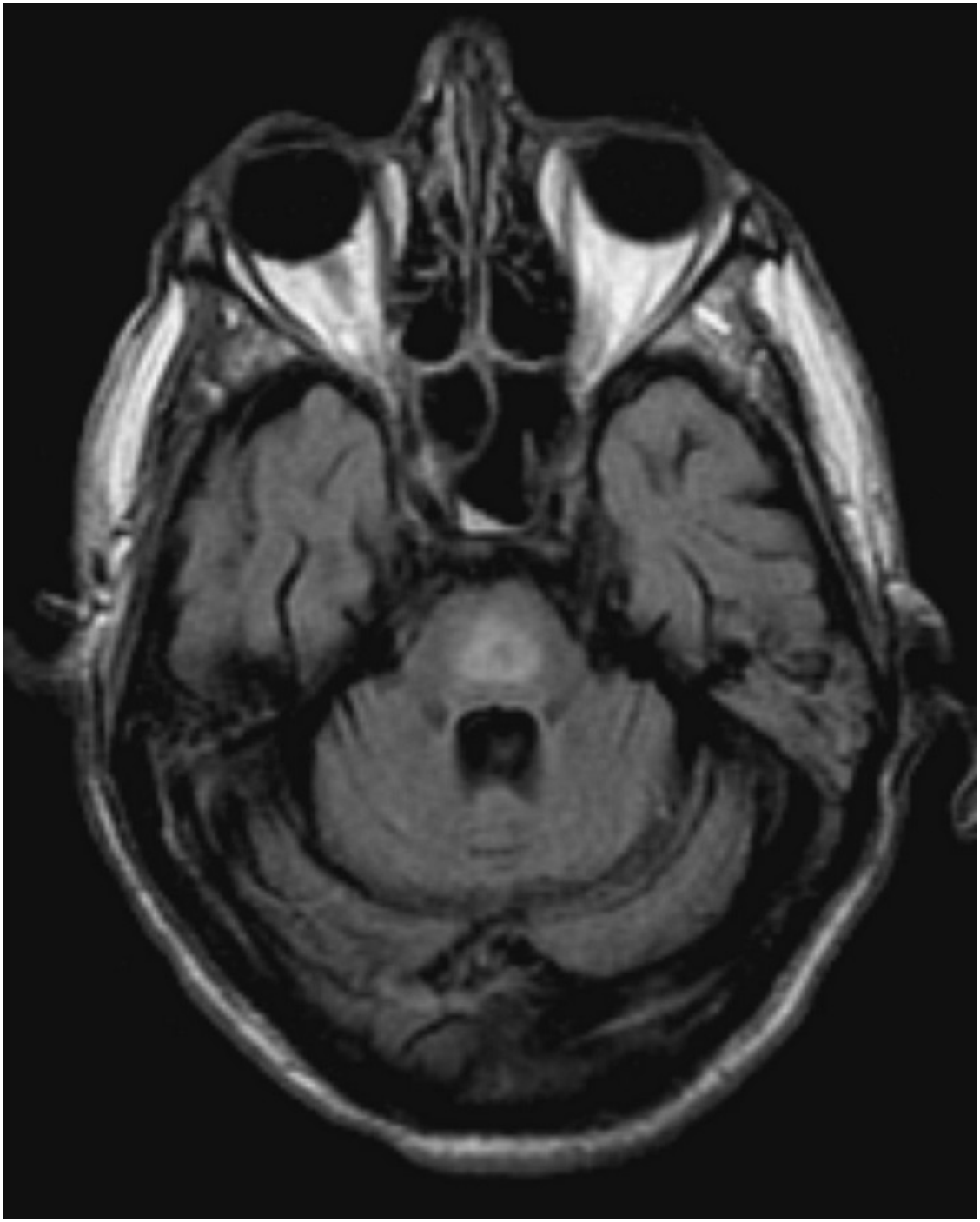
Effect of Na Ions on the RMP

Effect of Na Ions on the RMP

- **Hyponatremia**
- lethergy, confusion, weakness and muscle cramps, nausea and vomiting >>>> coma >>>>seizures
- Tt
- only 1 mlmol/L/hour
- Osmotic demyelination syndrome (central pontine myelinolysis)

Effect of Na Ions on the RMP

- **Hyponatremia**
- lethergy, confusion, weakness and muscle cramps, nausea and vomiting >>>> coma >>>>>seizures
- Tt
- only 1 mlmol/L/hour or (8 mmol/L of Na/day)
- Osmotic demyelination syndrome (central pontine myelinolysis)



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- **Hypernatremia**
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- Tt
- 0.45% sodium chloride
- brain edema or hemorrhage, potentially seizures, permanent brain damage, or death

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Effect of Ca Ions on the RMP

- **Hypercalcemia**

Effect of Ca Ions on the RMP

- **Hypercalcemia**

Headache, and lethargy. anxiety, depression, and cognitive dysfunction, insomnia, coma

Effect of Ca Ions on the RMP

- **Hypocalcemia**

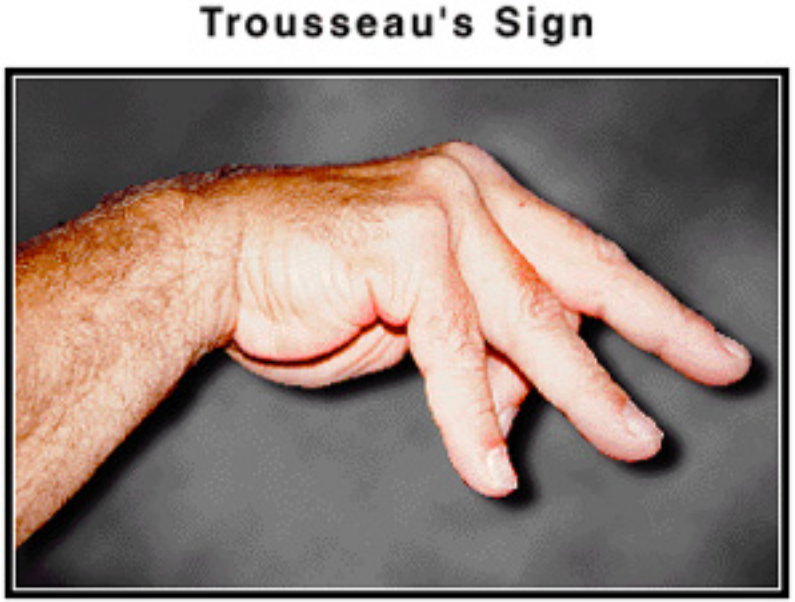
Effect of Ca Ions on the RMP

- **Hypocalcemia**

- The hallmark is neuromuscular irritability and tetany

(Trousseau's sign & Chvostek's sign)

- Irritability , hyperreflexia, Seizures, psychosis and hallucination



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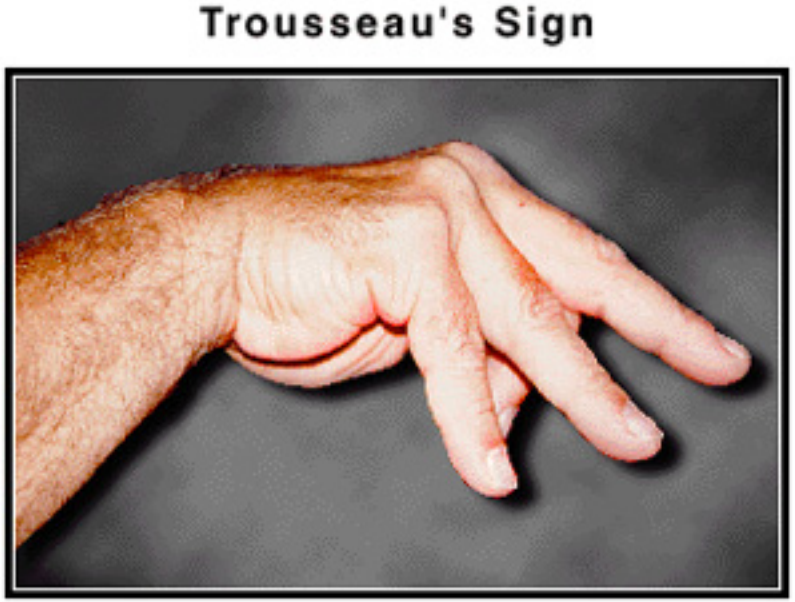

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