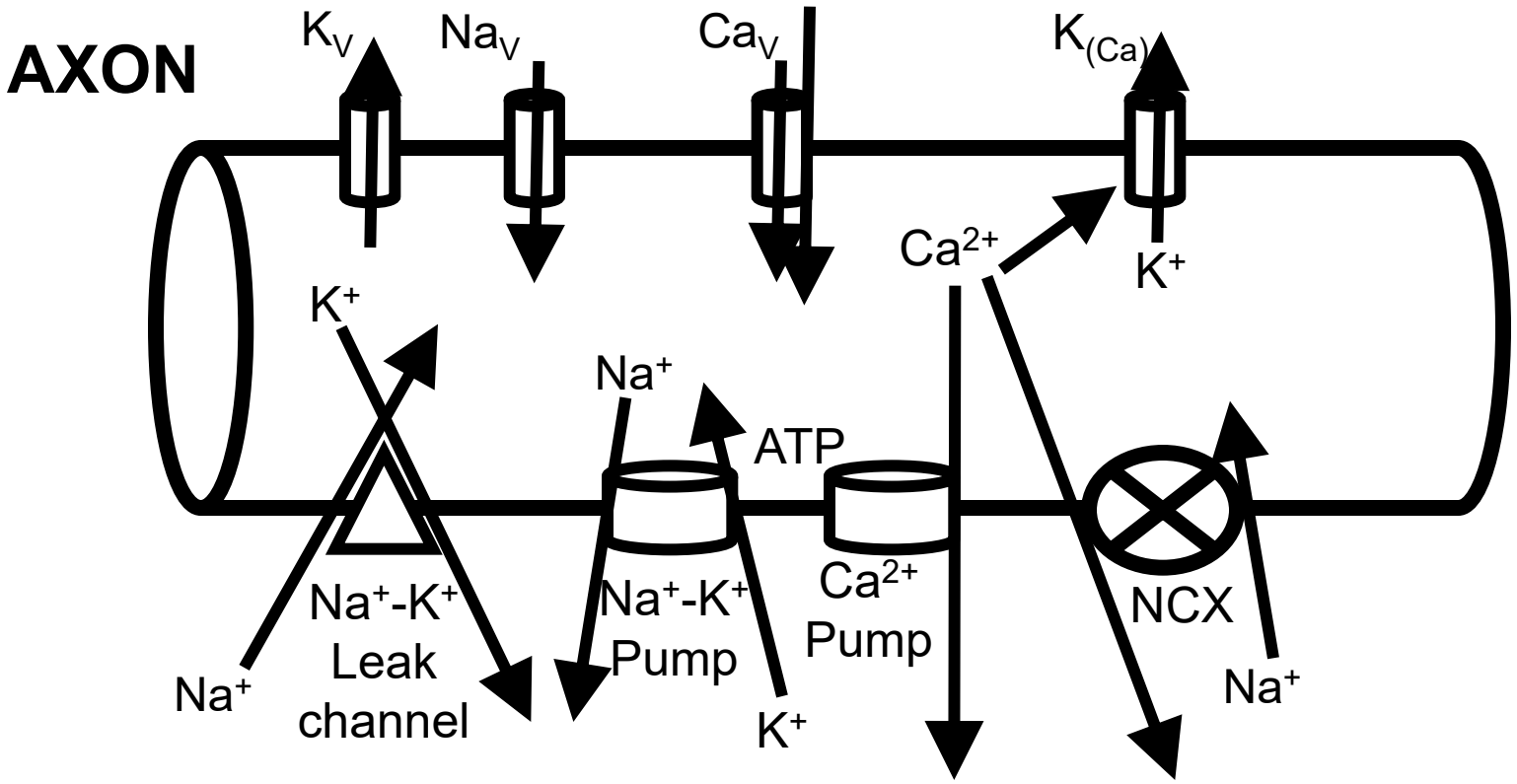
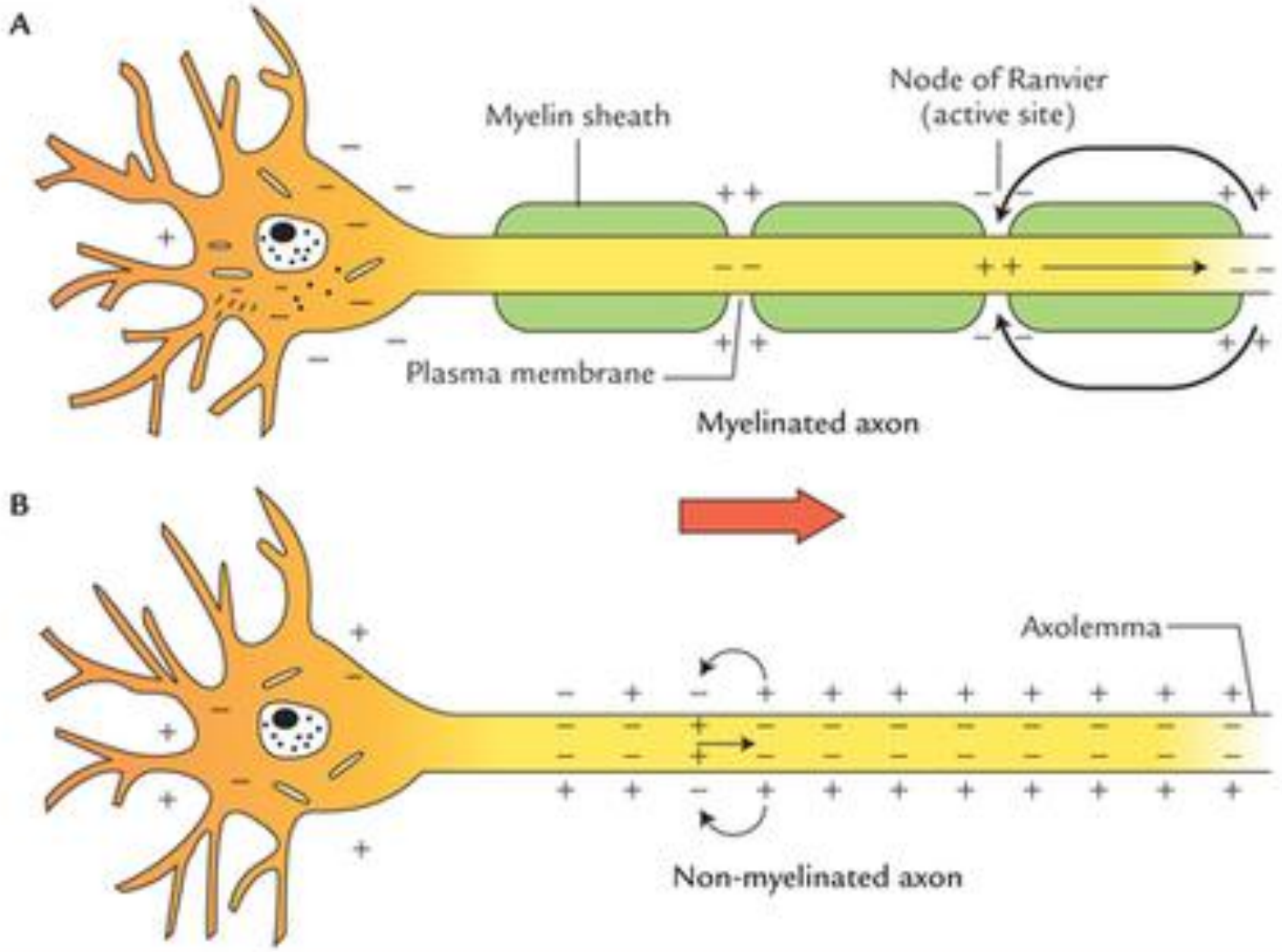



$K_V$, $Na_V$, $Ca_V$ are voltage gated ion channels

NCX is the $Na^+$-$Ca^{2+}$ exchanger

$K_{(Ca)}$ is the $Ca^{2+}$ activated $K^+$ channel




https://vivadifferences.com/myelinated-vs-unmyelinated-neurons/

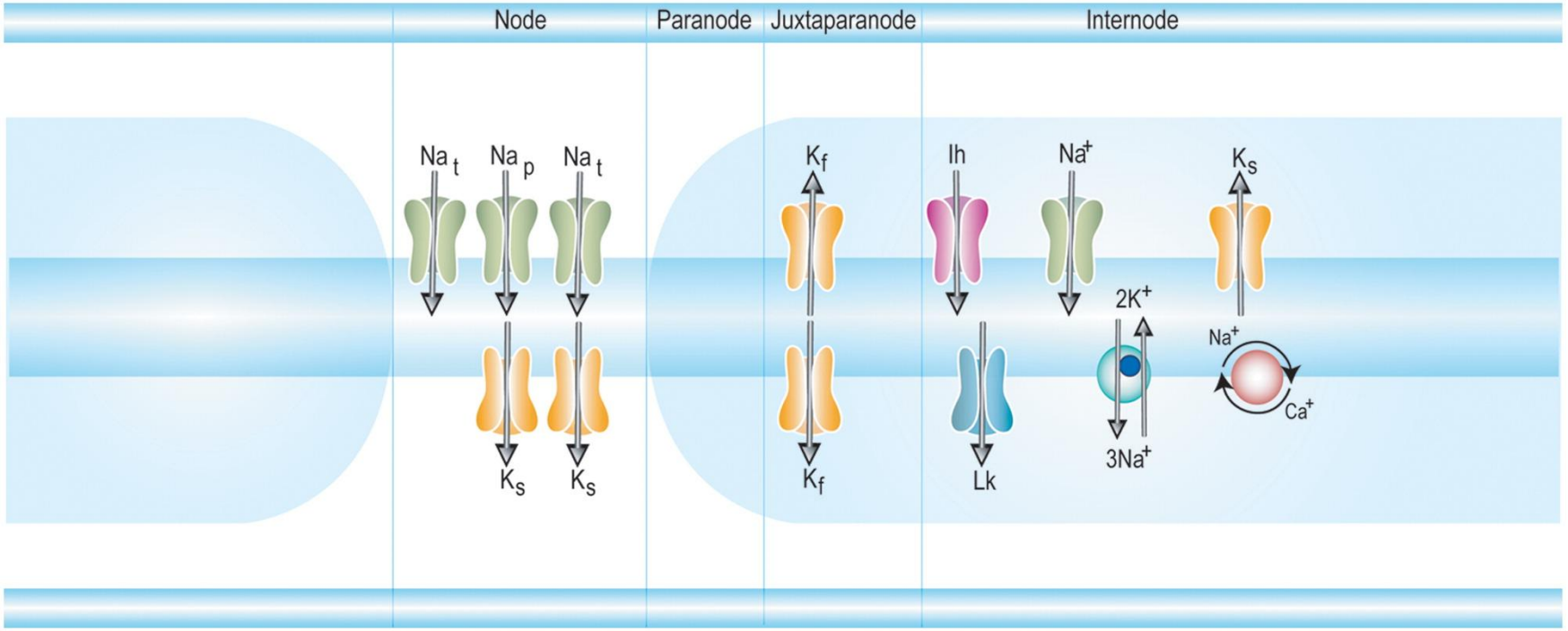
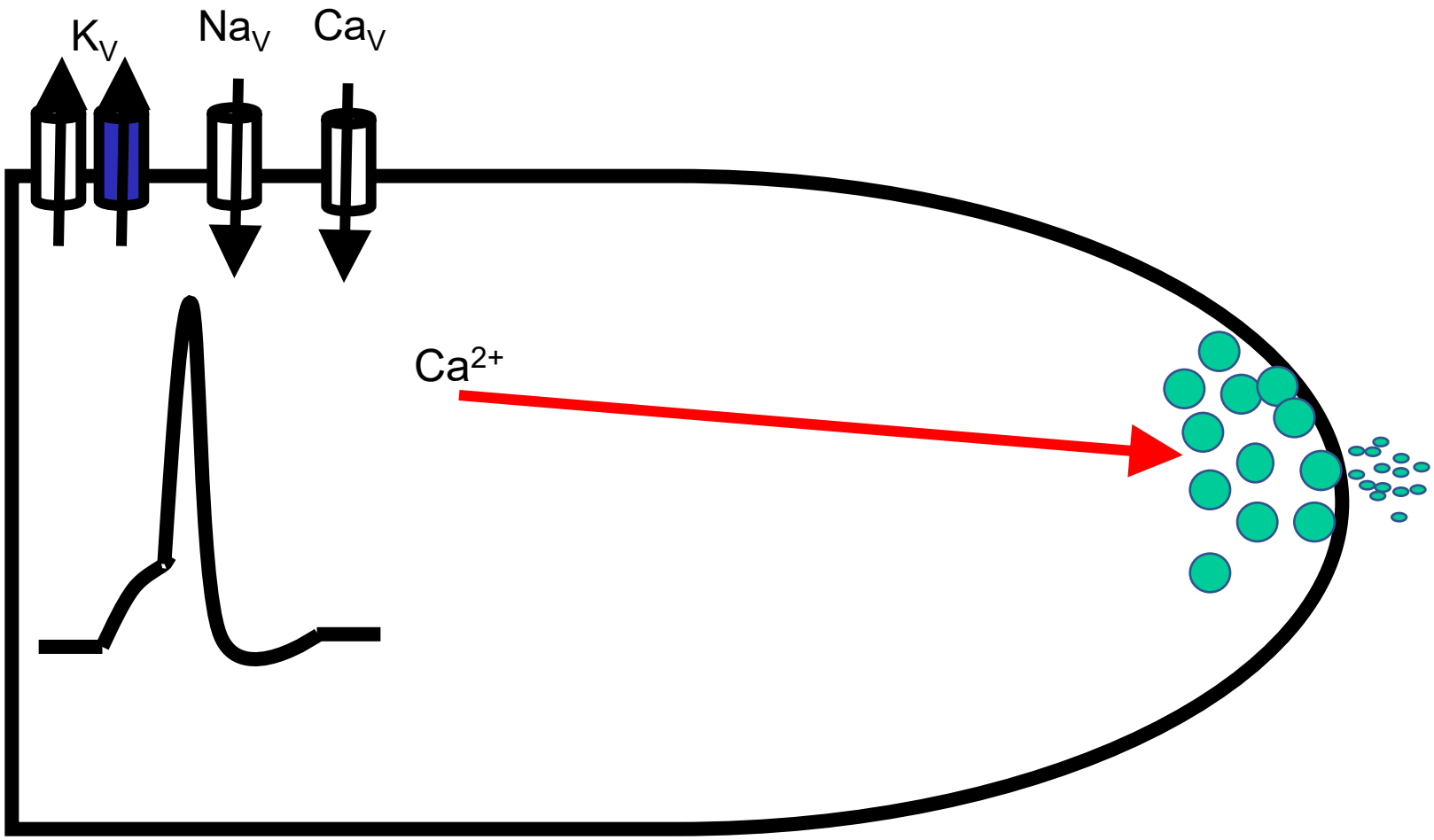



Figure 1. An overview of the various ion channels, pumps and exchangers that are important in axonal impulse conduction. Na+ channels are present in highest density at the Node of Ranvier as are slow K+ channels (Ks). Fast K+ channels, also known as Kv 1.1 channels are present in the highest concentration in the juxtaparanodal region and are blocked by 4-aminopyridine (fampridine). Inwardly rectifying channels (Ih) are permeable to Na+ and K+ ions and limit axonal hyperpolarisation. Transient Na+ channels (Nat) are responsible for action potential propagation while persistent Na+ conductances (Nap) modulate resting membrane potential. The sodium-calcium exchanger (Na+/Ca2+) plays an important role in the processes of axonal degeneration. Lk refers to leak conductances.

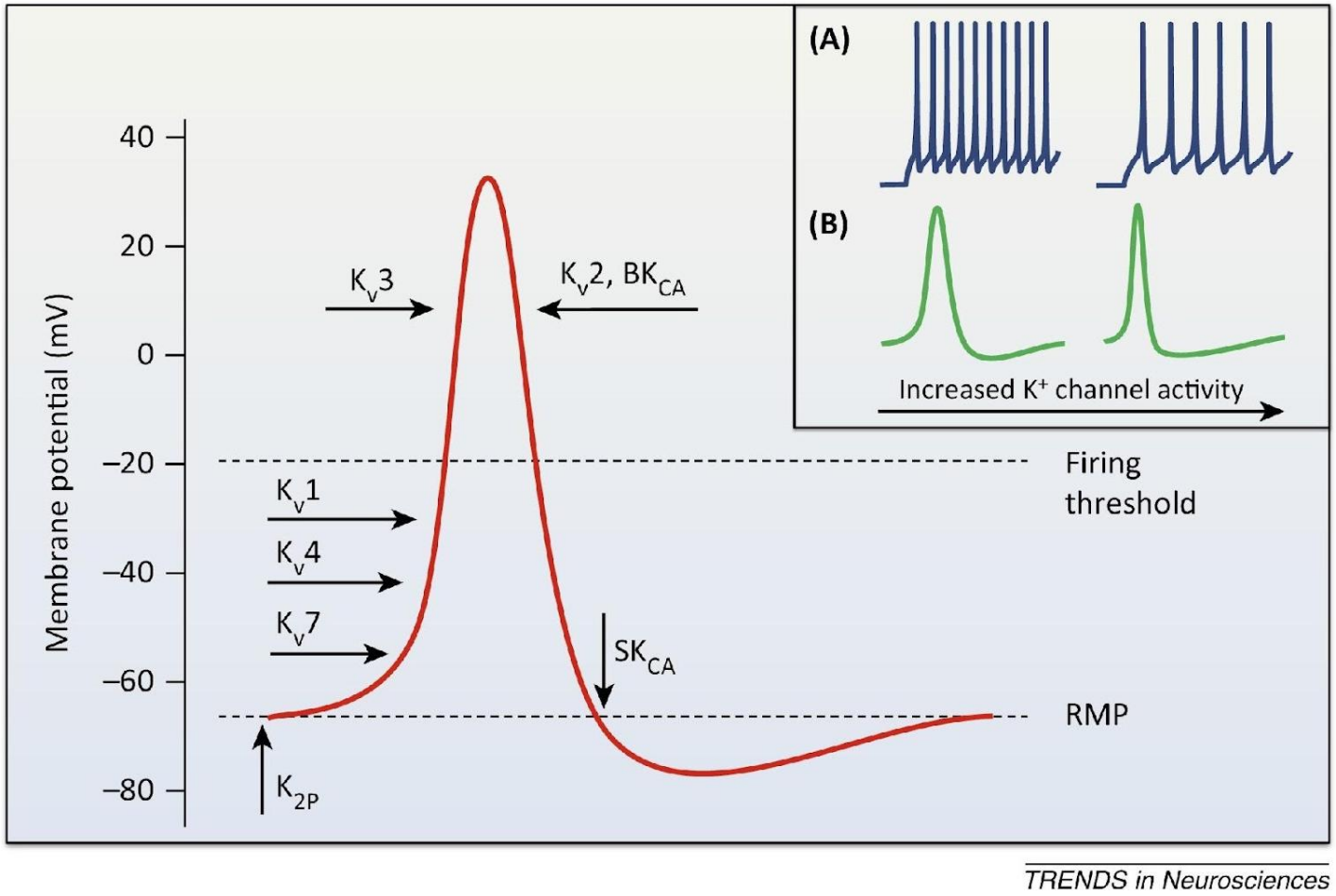
## 4-AP sensitive one



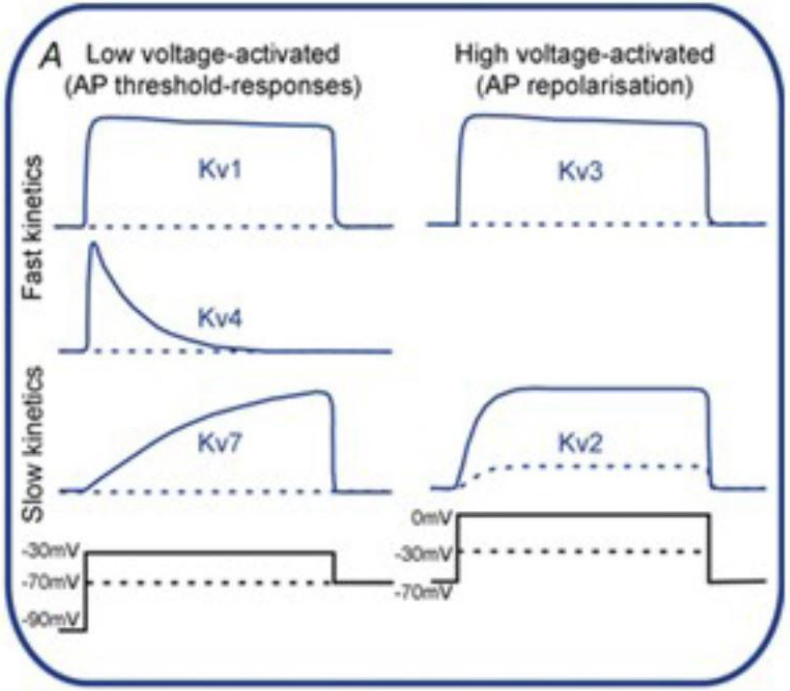
Goldman-Hodgkin-Katz (G-H-K) equation

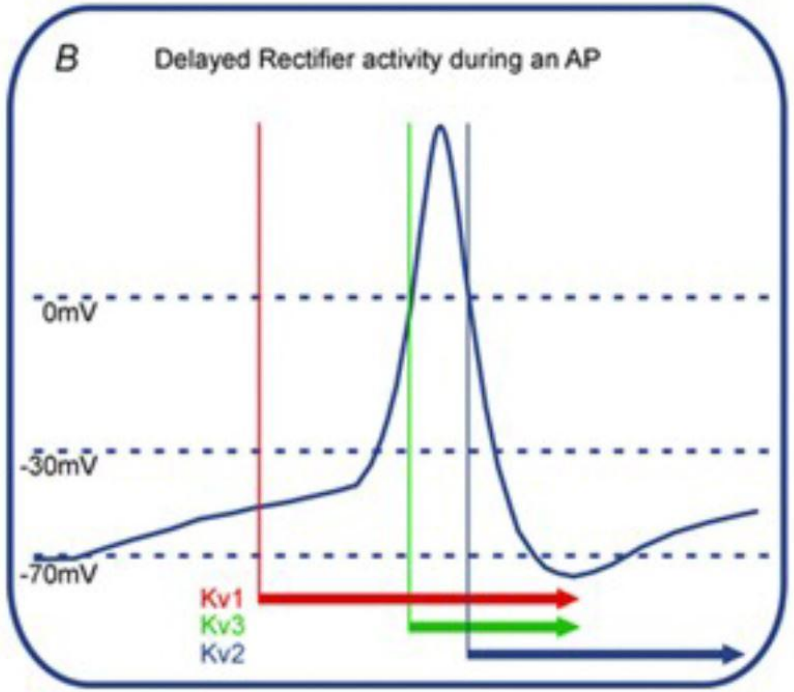
Here is a generalized G-H-K equation for $Na^+$, $K^+$, and $Cl^-$ ions:

$$Em_{K,Na,Cl} = \frac{RT}{F} lnln \frac{P_{Na^+}[Na^+]_{out} + P_{K^+}[K^+]_{out} + PCl[Cl]in}{P_{Na^+}[Na^+]_{in} + P_{K^+}[K^+]_{in} + PCl[Cl]out}$$

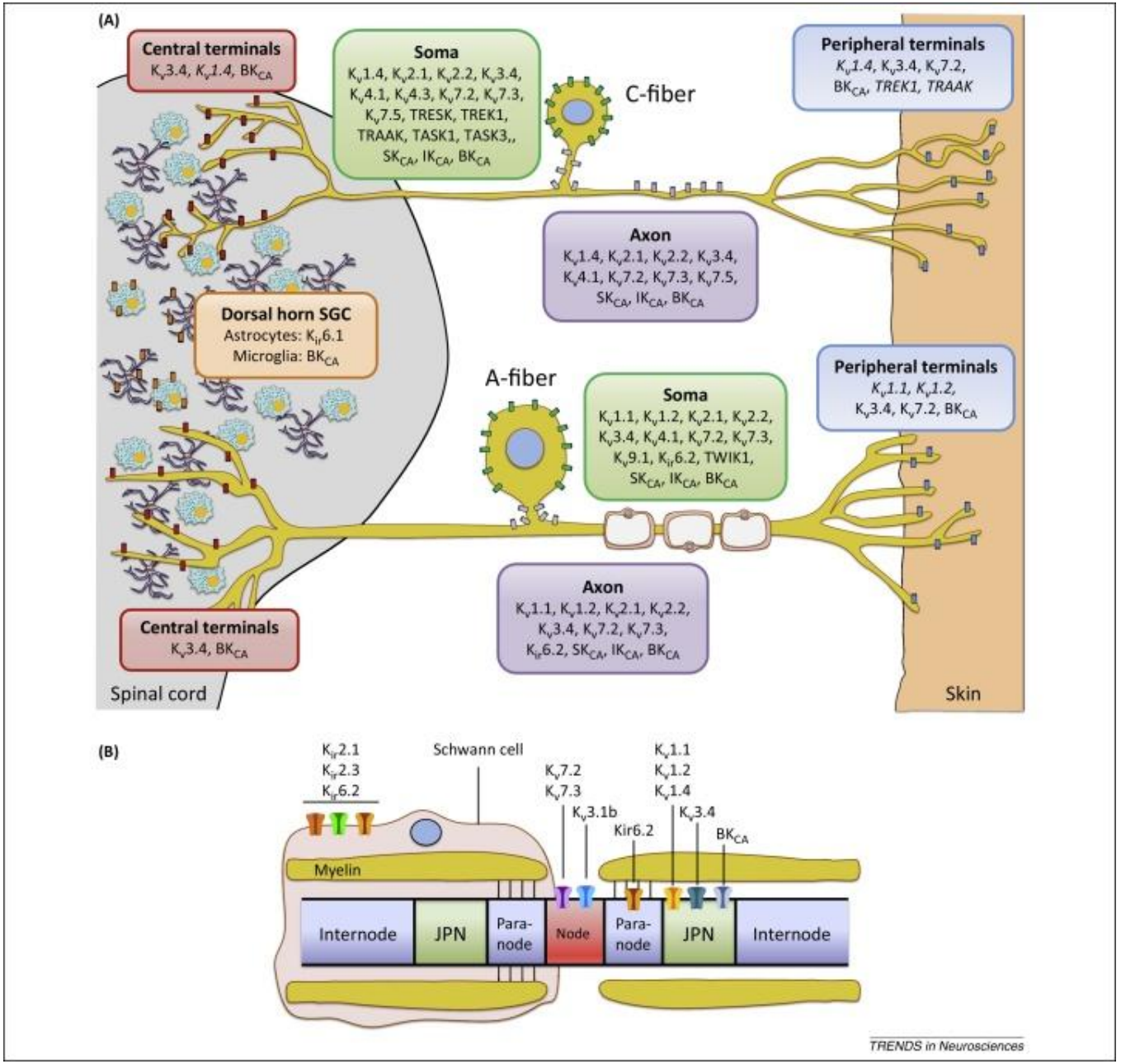



Tsantoulas C, McMahon SB. Opening paths to novel analgesics: the role of potassium channels in chronic pain. Trends Neurosci. 2014 Mar;37(3):146-58. doi: 10.1016/j.tins.2013.12.002. Epub 2014 Jan 21. PMID: 24461875; PMCID: PMC3945816.

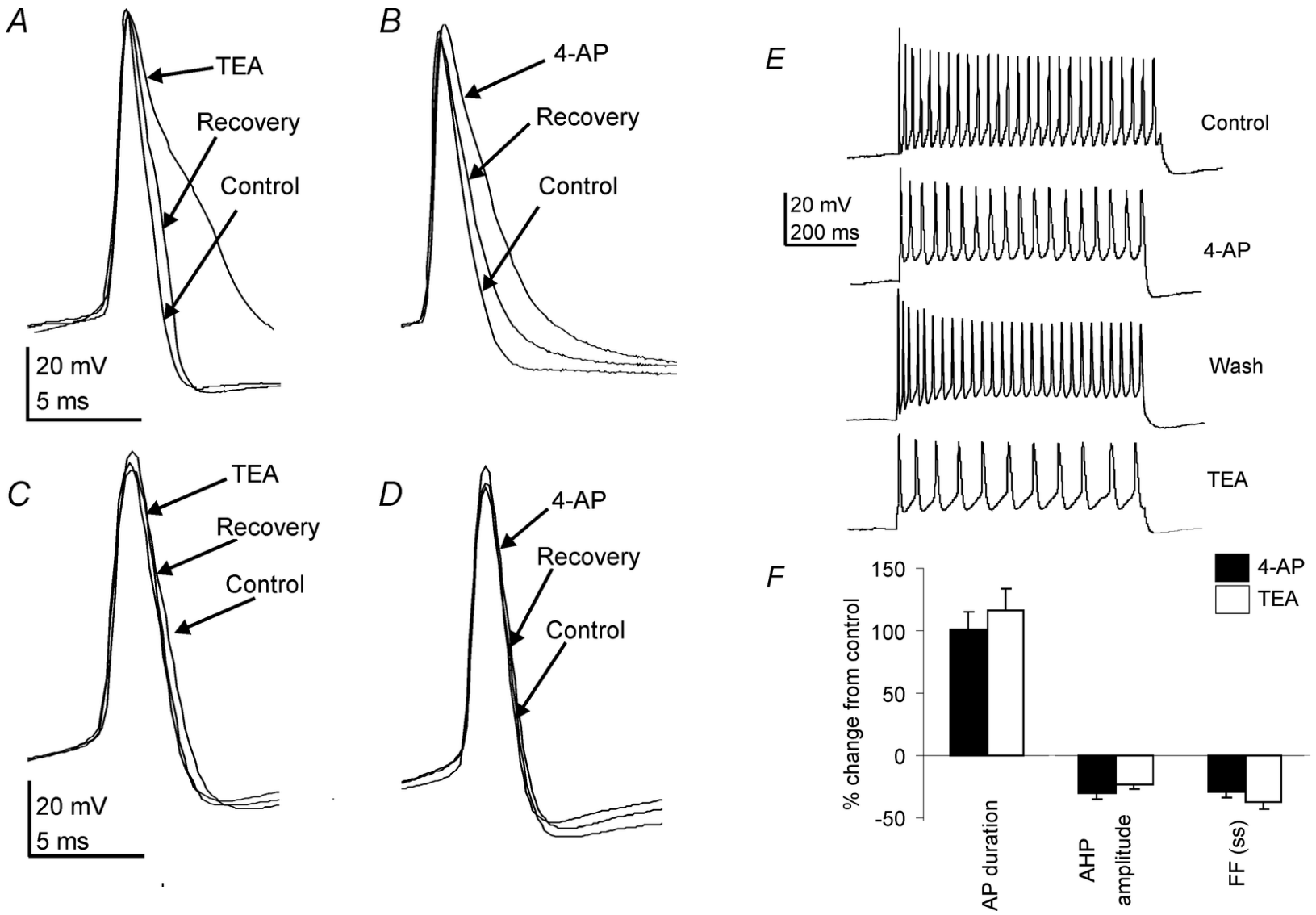


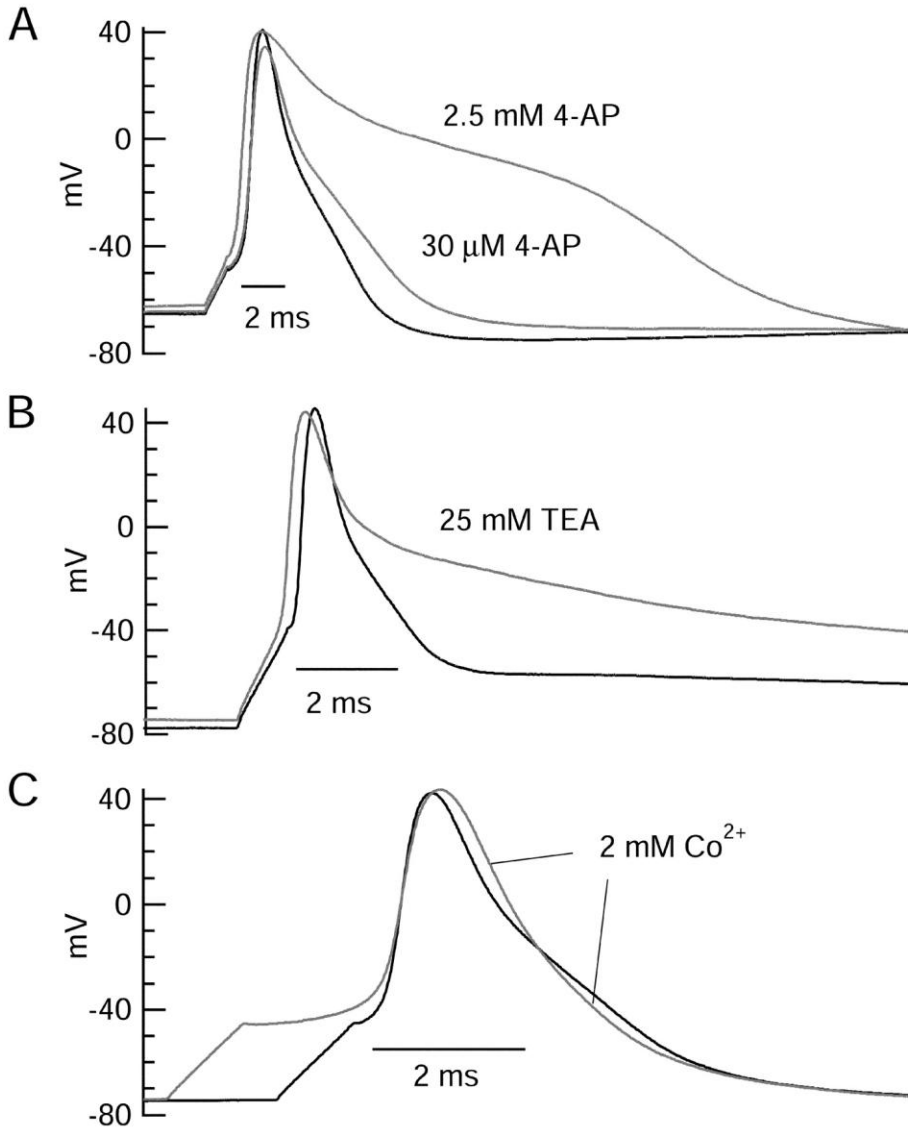

Johnston, J., I.D. Forsythe, and C. Kopp-Scheinpflug, Going native: voltage-gated potassium channels controlling neuronal excitability. J Physiol, 2010. 588(Pt 17): p. 3187-200




Tsantoulas C, McMahon SB. Opening paths to novel analgesics: the role of potassium channels in chronic pain. Trends Neurosci. 2014 Mar;37(3):146-58. doi: 10.1016/j.tins.2013.12.002. Epub 2014 Jan 21. PMID: 24461875; PMCID: PMC3945816.




Dallas ML, Atkinson L, Milligan CJ, Morris NP, Lewis DI, Deuchars SA, Deuchars J. Localization and function of the Kv3.1b subunit in the rat medulla oblongata: focus on the nucleus tractus solitarii. J Physiol. 2005 Feb 1;562(Pt 3):655-72. doi: 10.1113/jphysiol.2004.073338. Epub 2004 Nov 4. PMID: 15528247; PMCID: PMC1665536.




The overall voltage-dependent potassium current in the neurons could be split into three major components based on pharmacology and kinetics during step voltage pulses: $I_D$ (fast activating, slowly inactivating, and sensitive to 4-aminopyridine at 30 µm),$I_A$ (fast activating, fast inactivating, and sensitive to 4-aminopyridine at 3 mm), and$I_K$ (slowly activating, noninactivating, and sensitive to external TEA at 3–25 mm). The potassium current during the action potential was composed of approximately equal contributions of $I_D$ and$I_A$, with a negligible contribution of$I_K$.

https://www.jneurosci.org/content/22/23/10106

Mitterdorfer J, Bean BP. Potassium currents during the action potential of hippocampal CA3 neurons. J Neurosci. 2002 Dec 1;22(23):10106-15. doi: 10.1523/JNEUROSCI.22-23-10106.2002. PMID: 12451111; PMCID: PMC6758734.