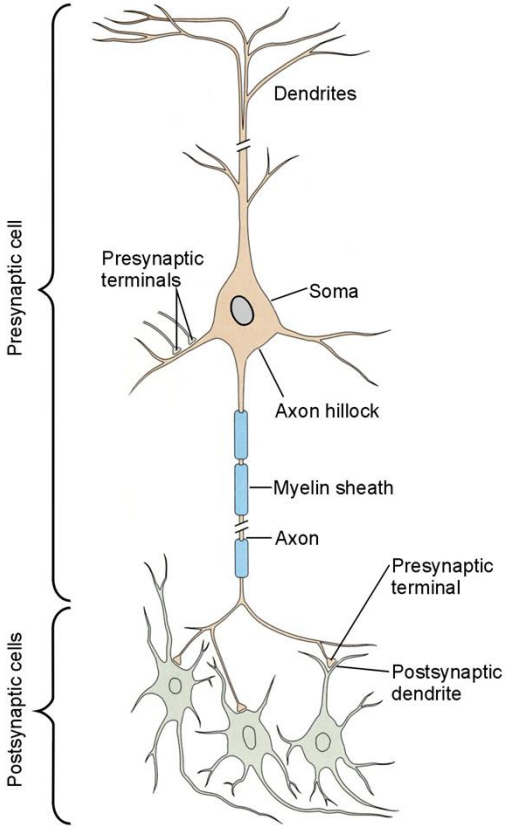
Das Gehirn:

Eine Einführung in die Molekulare Neurobiologie

A. Baumann

Entstehung des Aktionspotenzials



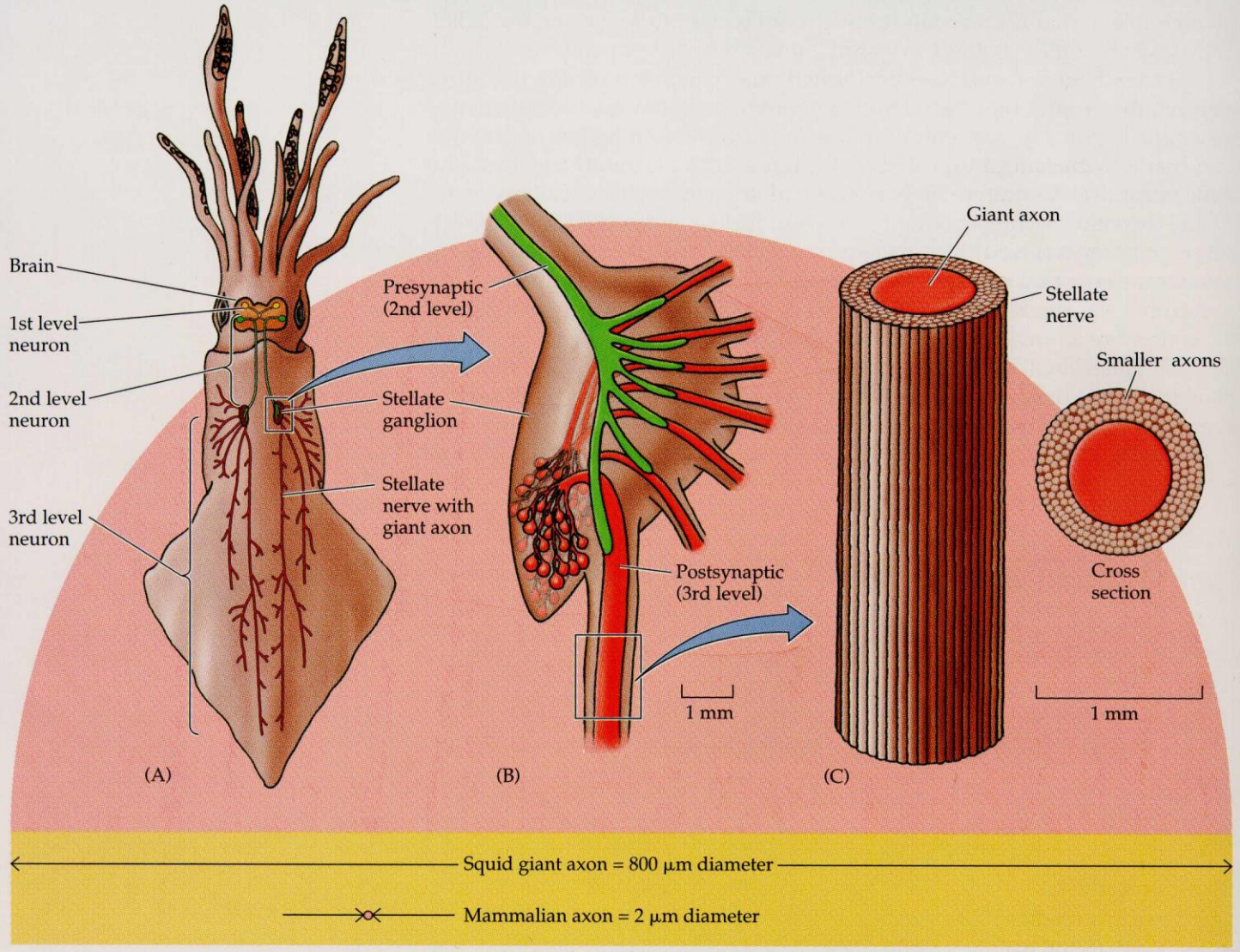
Typische Ionenverteilung bei Säugetieren

	außen	innen
Na^+	140 mM	3-30 mM
K^+	5 mM	140 mM
Ca^{2+}	2 mM	< 1µM
Mg^{2+}	2 mM	2-5 mM
Cl^-	140 mM	10 mM

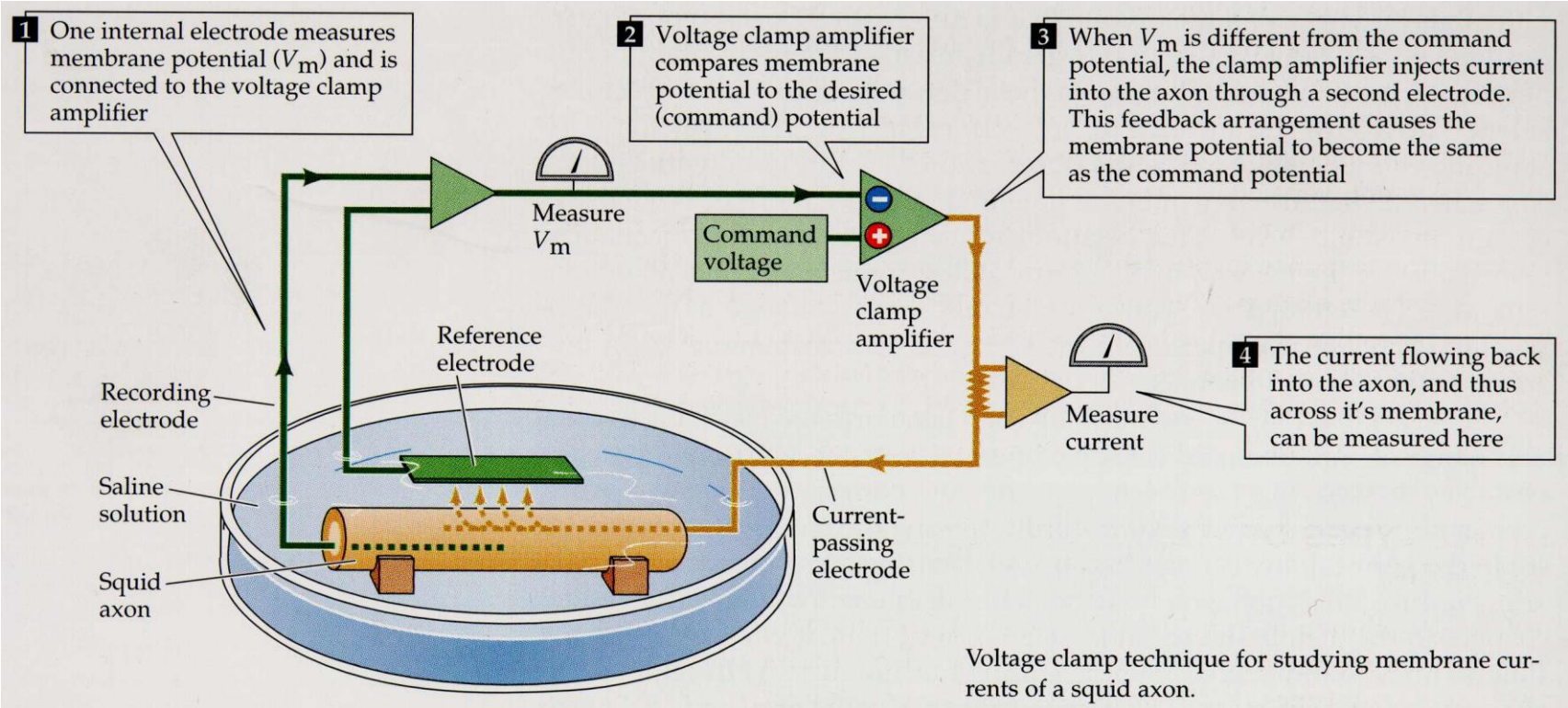
Elektrochemisches Potenzial

-70 mV

Riesenaxone eines Tintenfischs



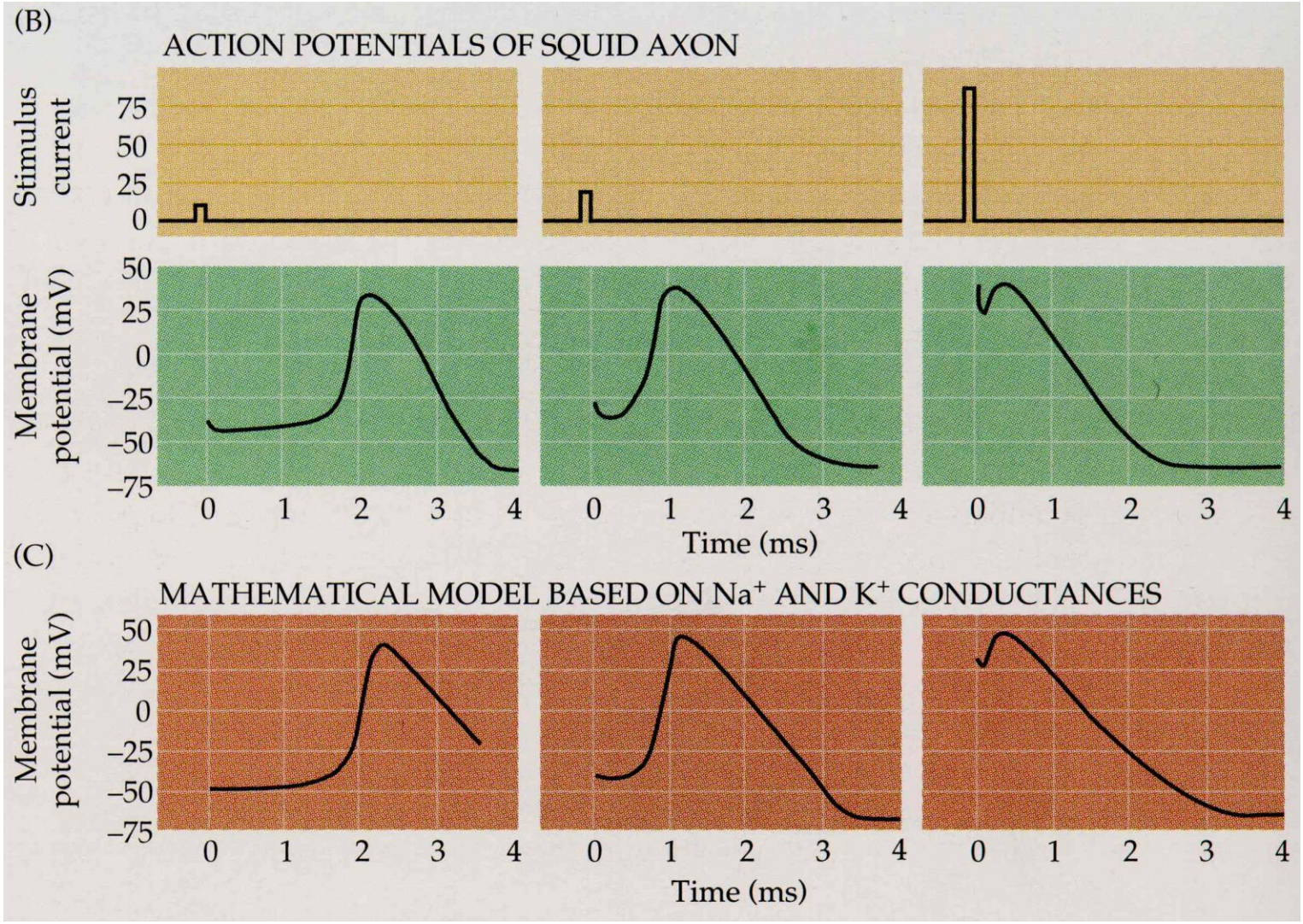
Messmethode - Spannungsklemme



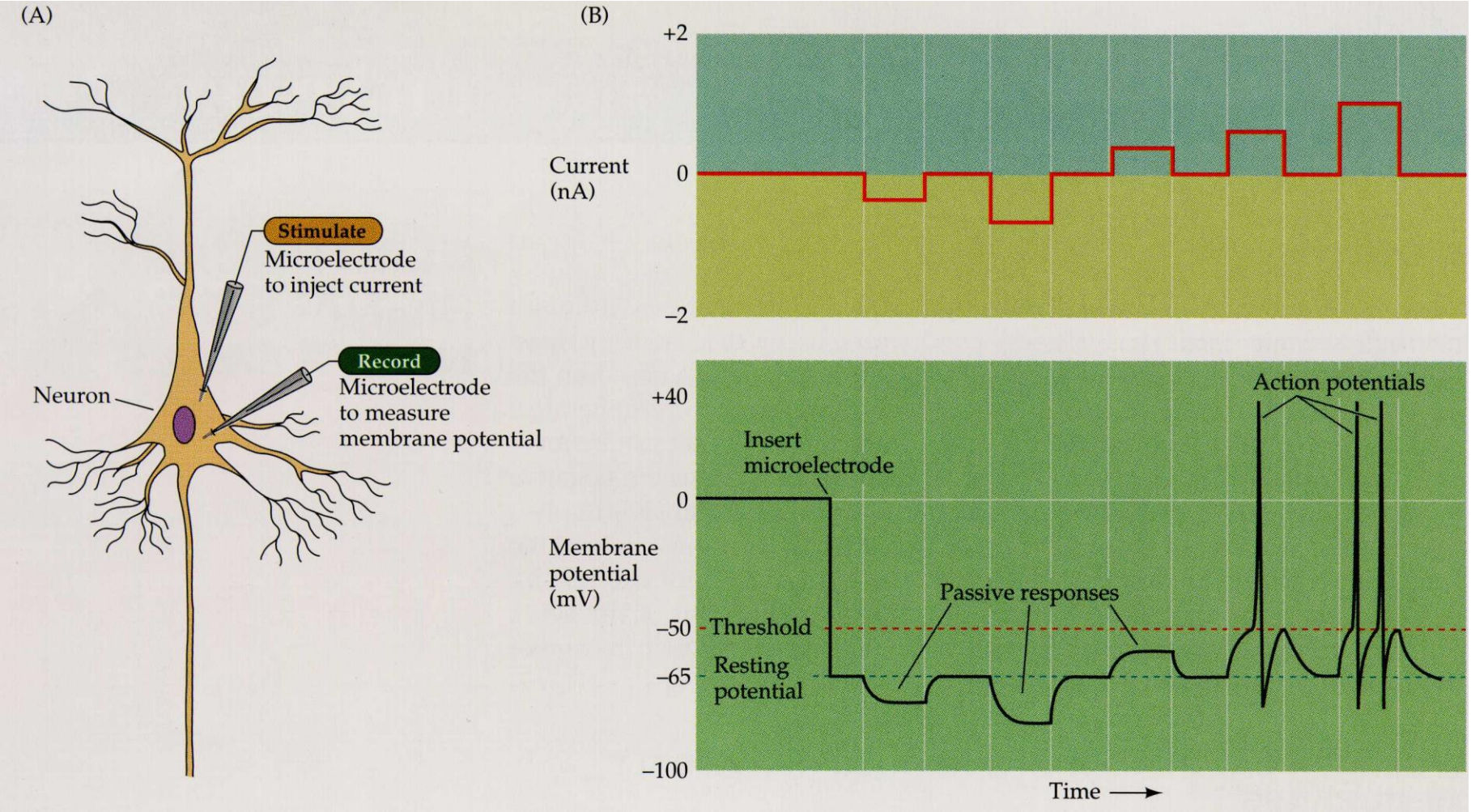
Voltage clamp technique for studying membrane currents of a squid axon.

Cole, K.S. (1968)

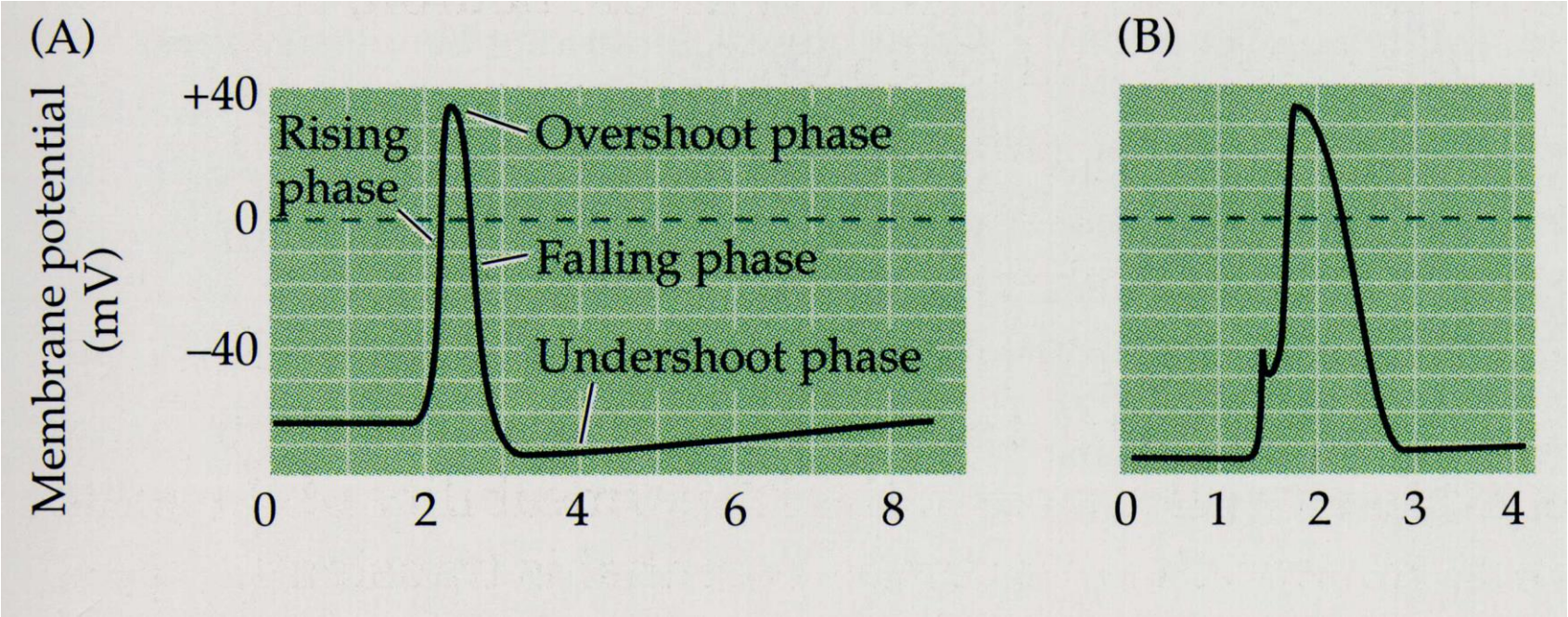
Messung am Riesenaxon



Messung an Neuronen

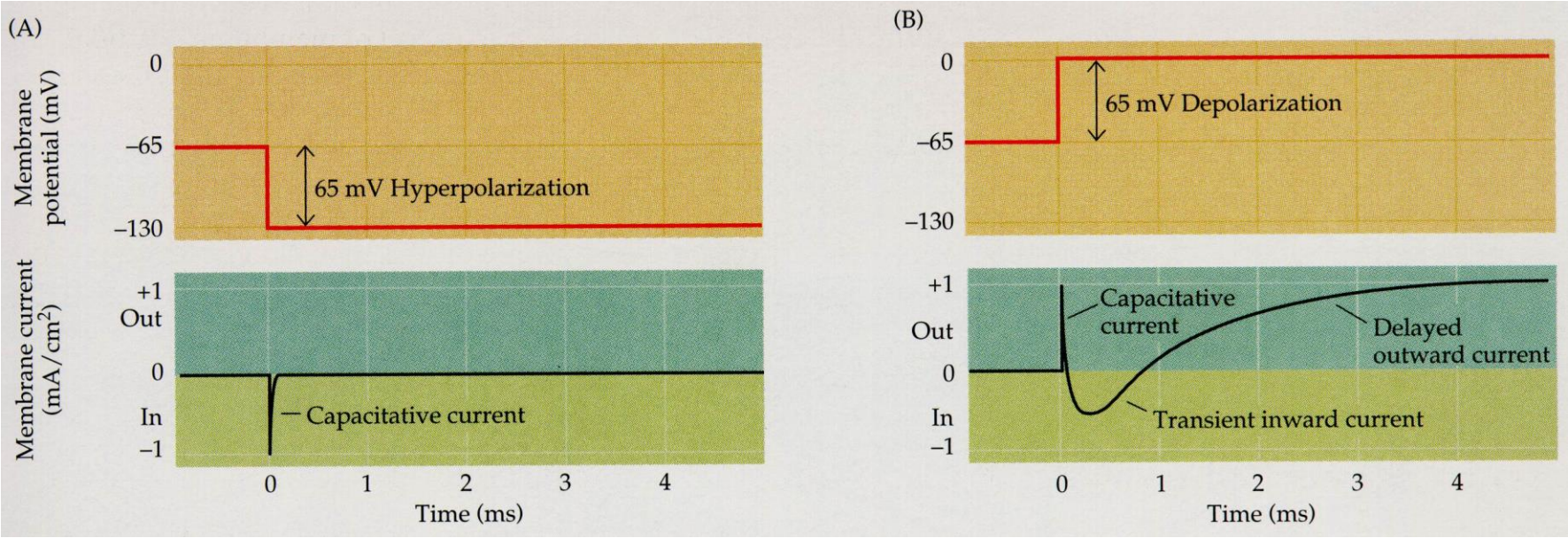


Aktionspotenzial „Nomenklatur“



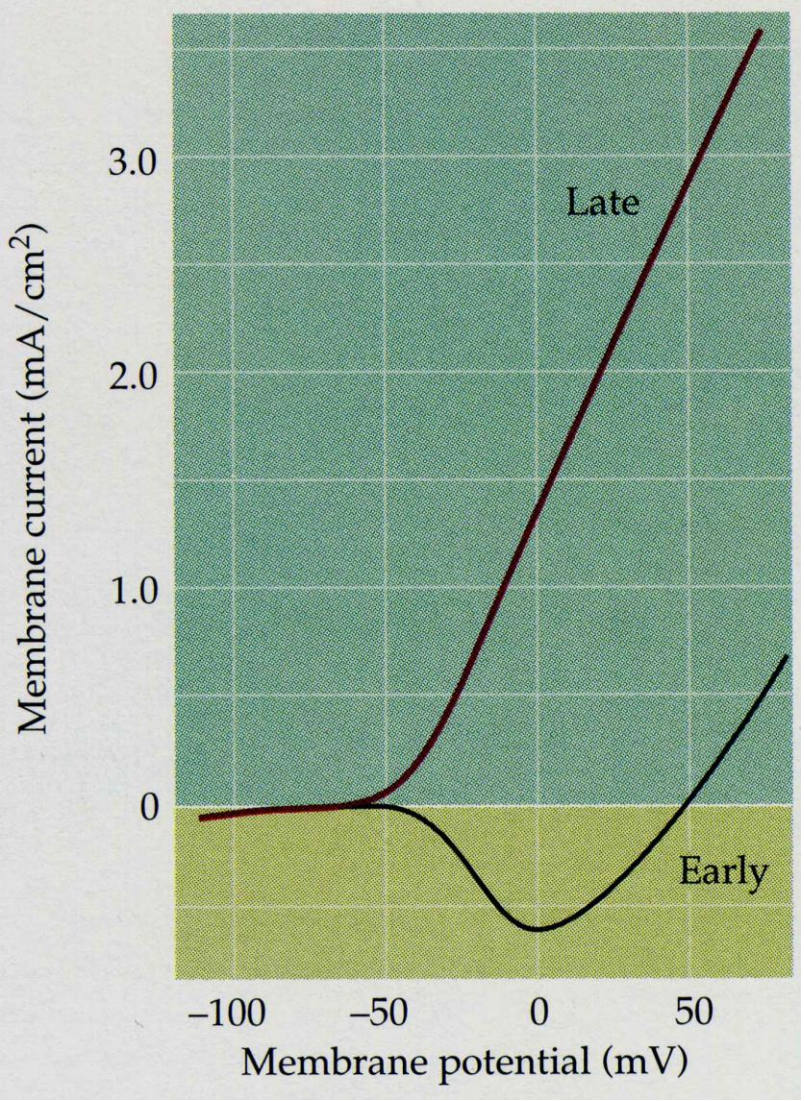
Myeliniertes Axon eines Motorneurons (Frosch)

Einwärts / Auswärtsströme

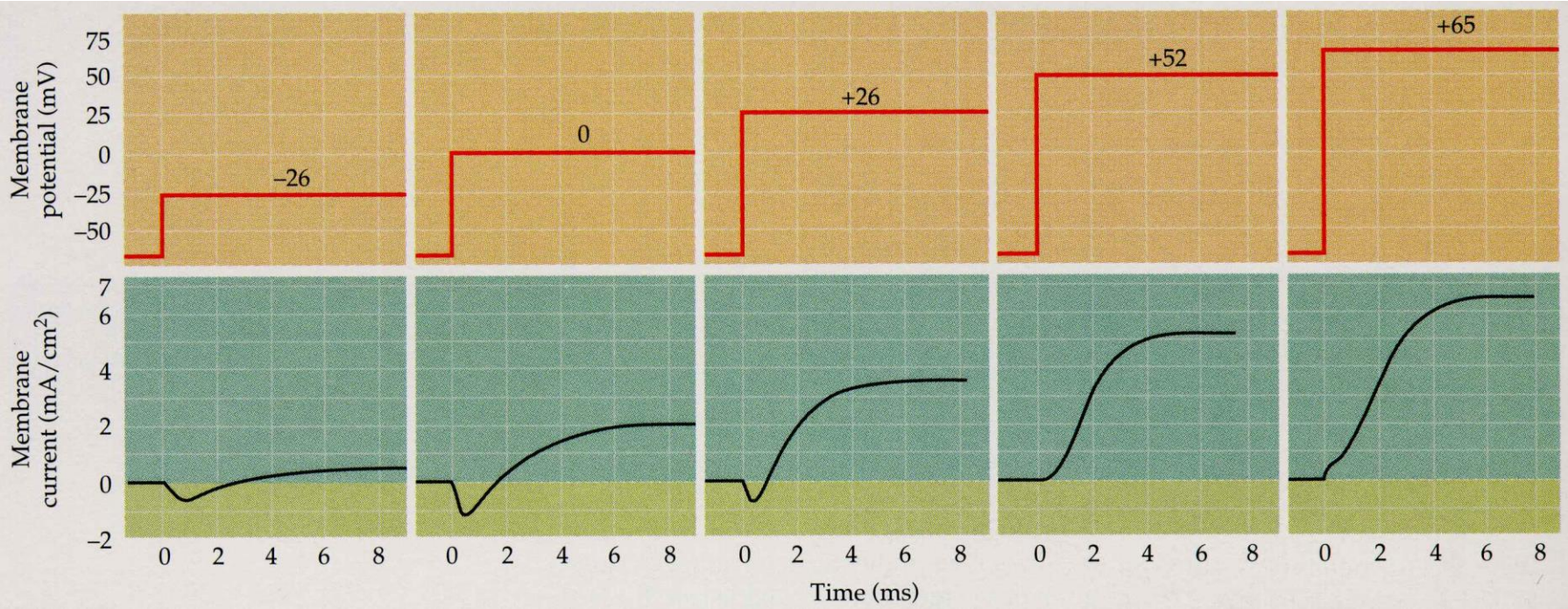


Hyperpolarisation: Membranpotenzial wird negativer als Ruhepotenzial
Depolarisation: Membranpotenzial wird positiver als Ruhepotenzial

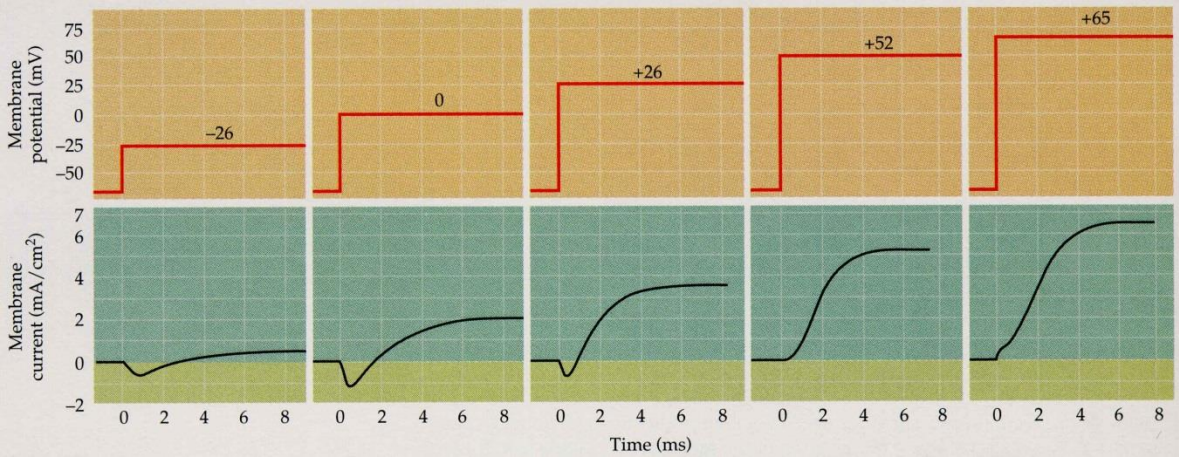
Zeitverlauf



Zeitverlauf / Stromrichtung



Ionengleichgewichte an Membranen



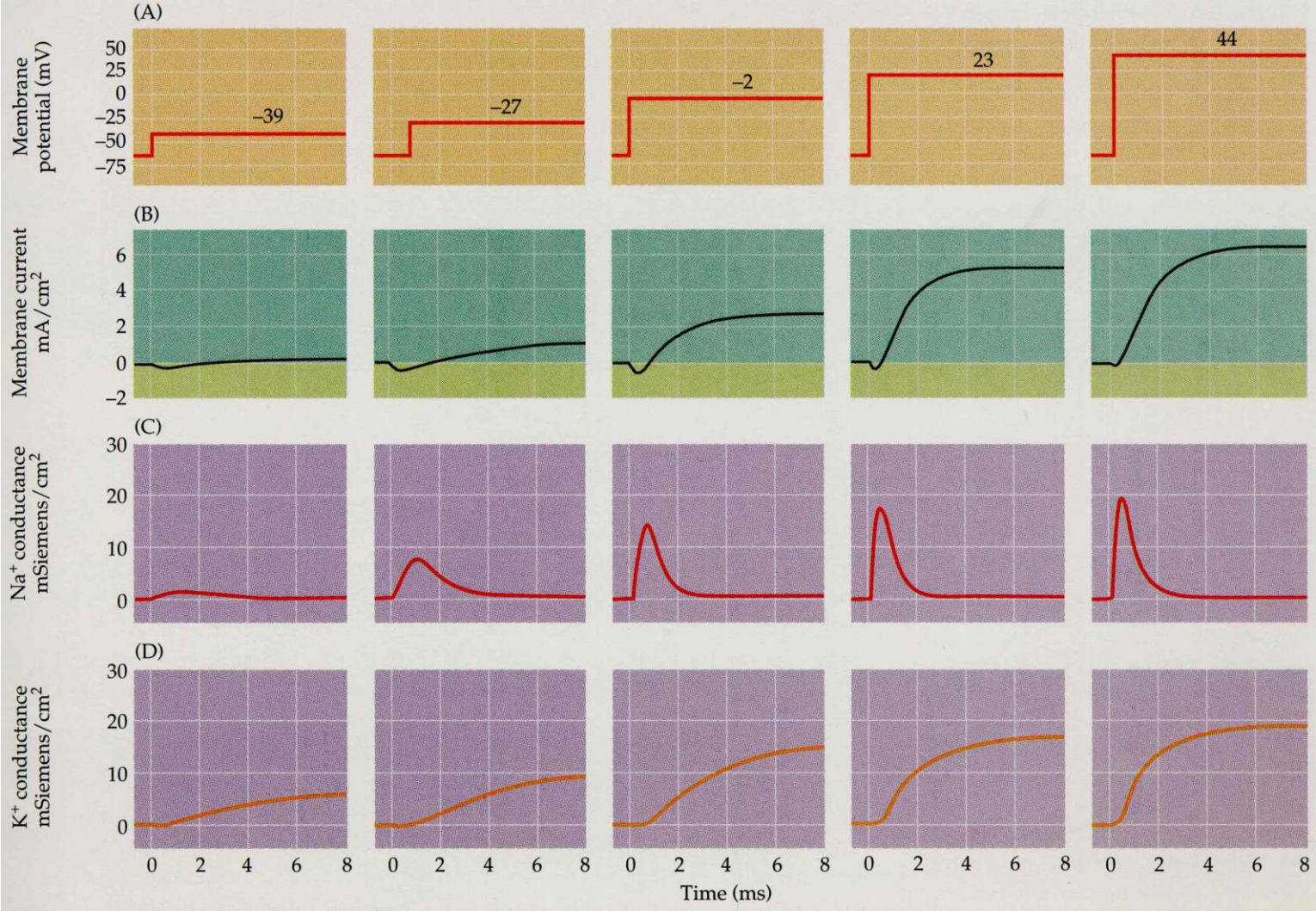
$$E_x = 58\ \text{mV} \log [X]_a/[X]_i$$

K^+ innen 140 mM/ außen 5 mM: E_K = -84 mV

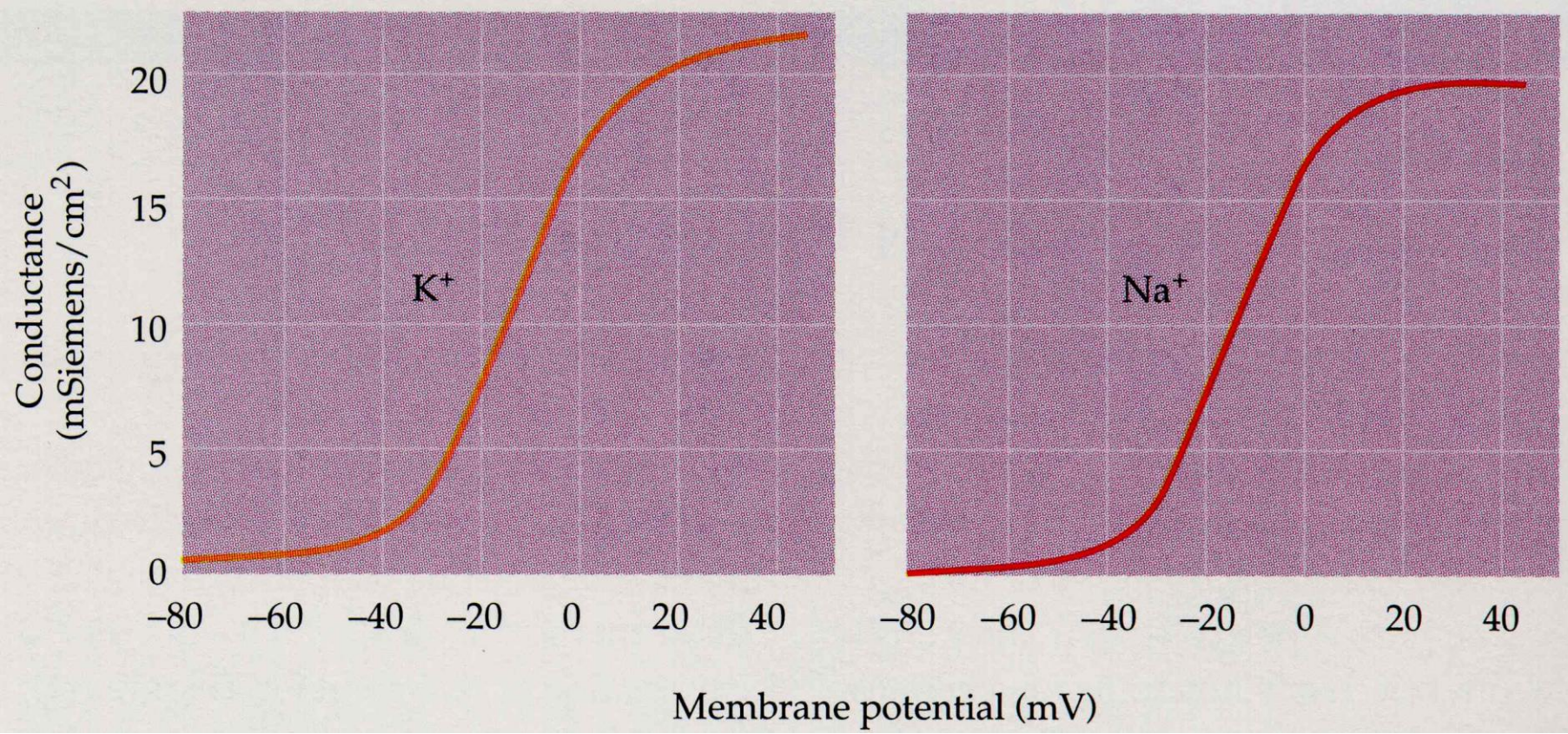
Na^+ innen 3 mM/ außen 140 mM: E_{Na} = 96 mV

Umkehrpotenzial

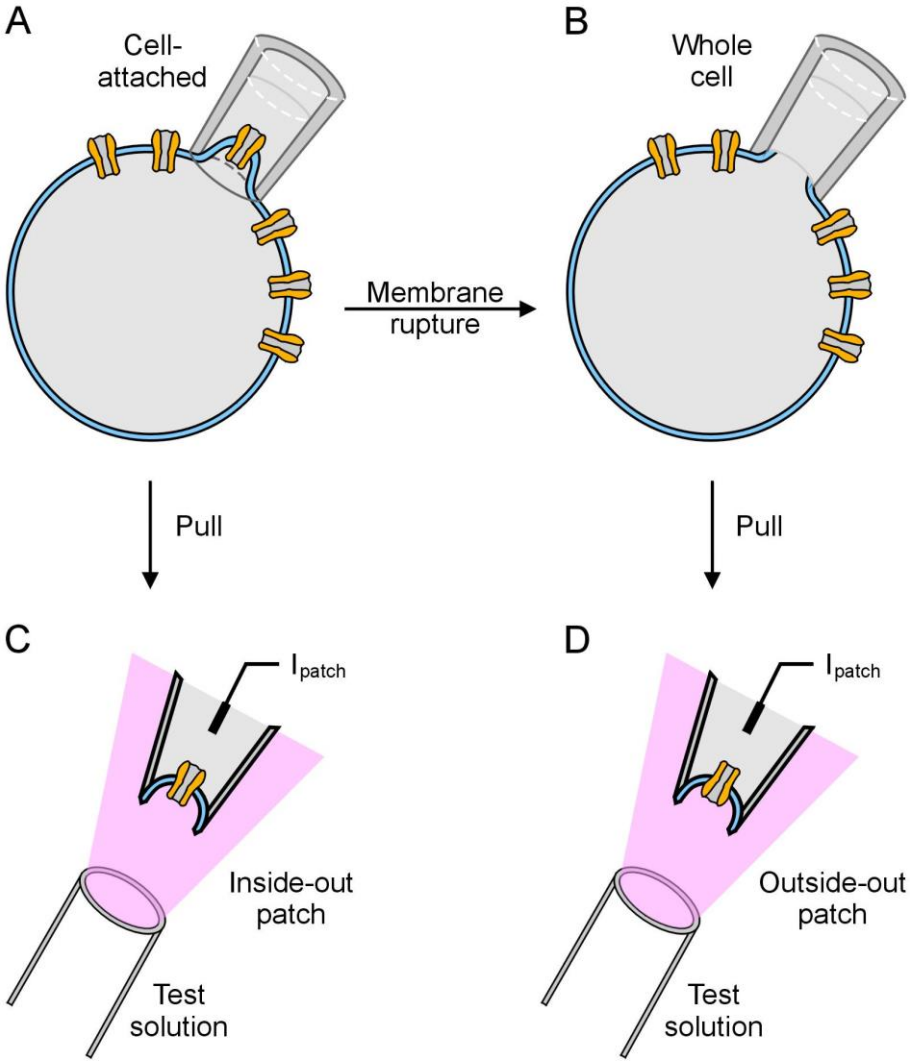
Beitrag Natrium-Ionen / Kalium-Ionen



Aktivierungsprofile K^+/Na^+ Leitfähigkeiten

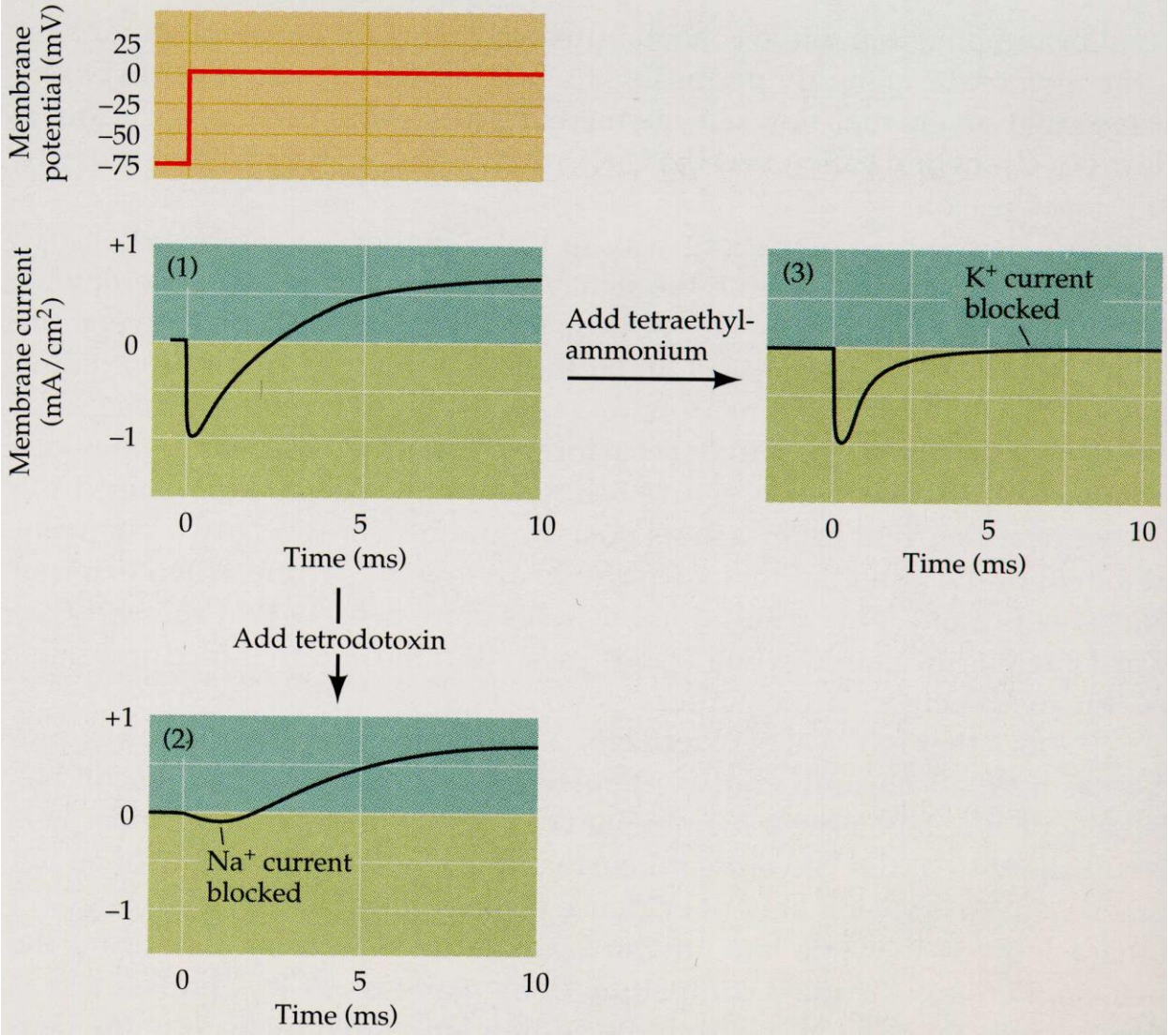


Messmethoden – Patch Clamp

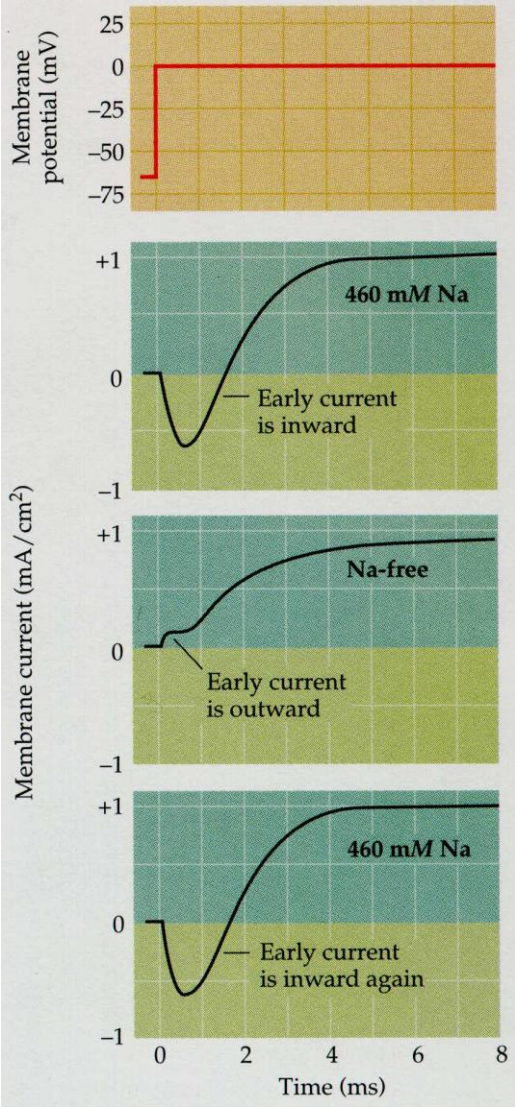


Excised-patch configurations

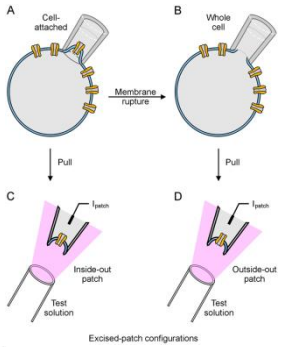
Pharmakologische „Manipulation“

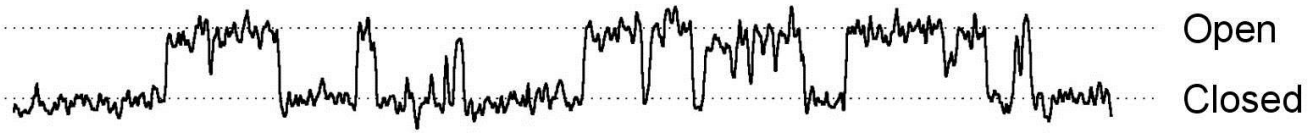


Ionenaustauschexperimente



Messung von Einzelkanalströmen

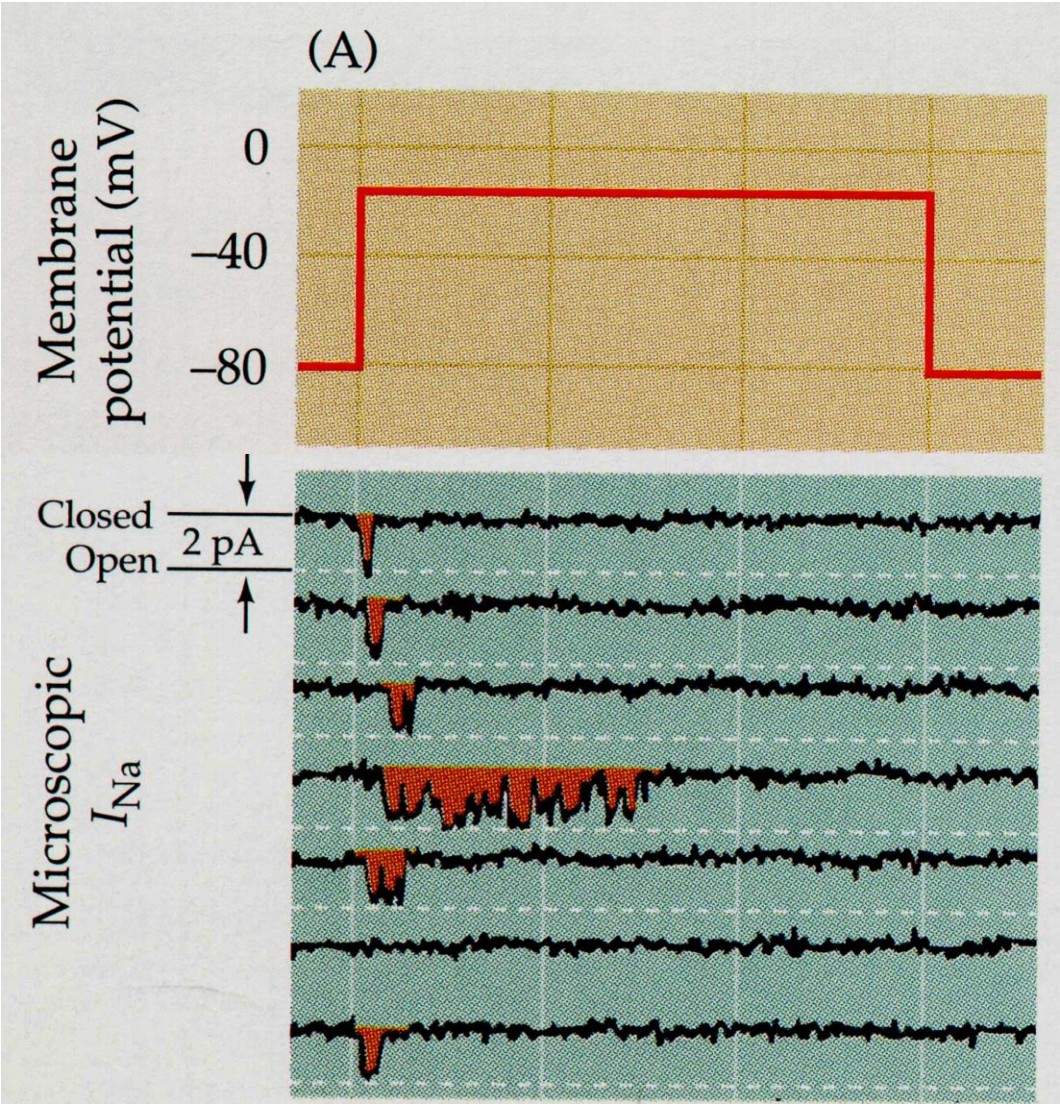




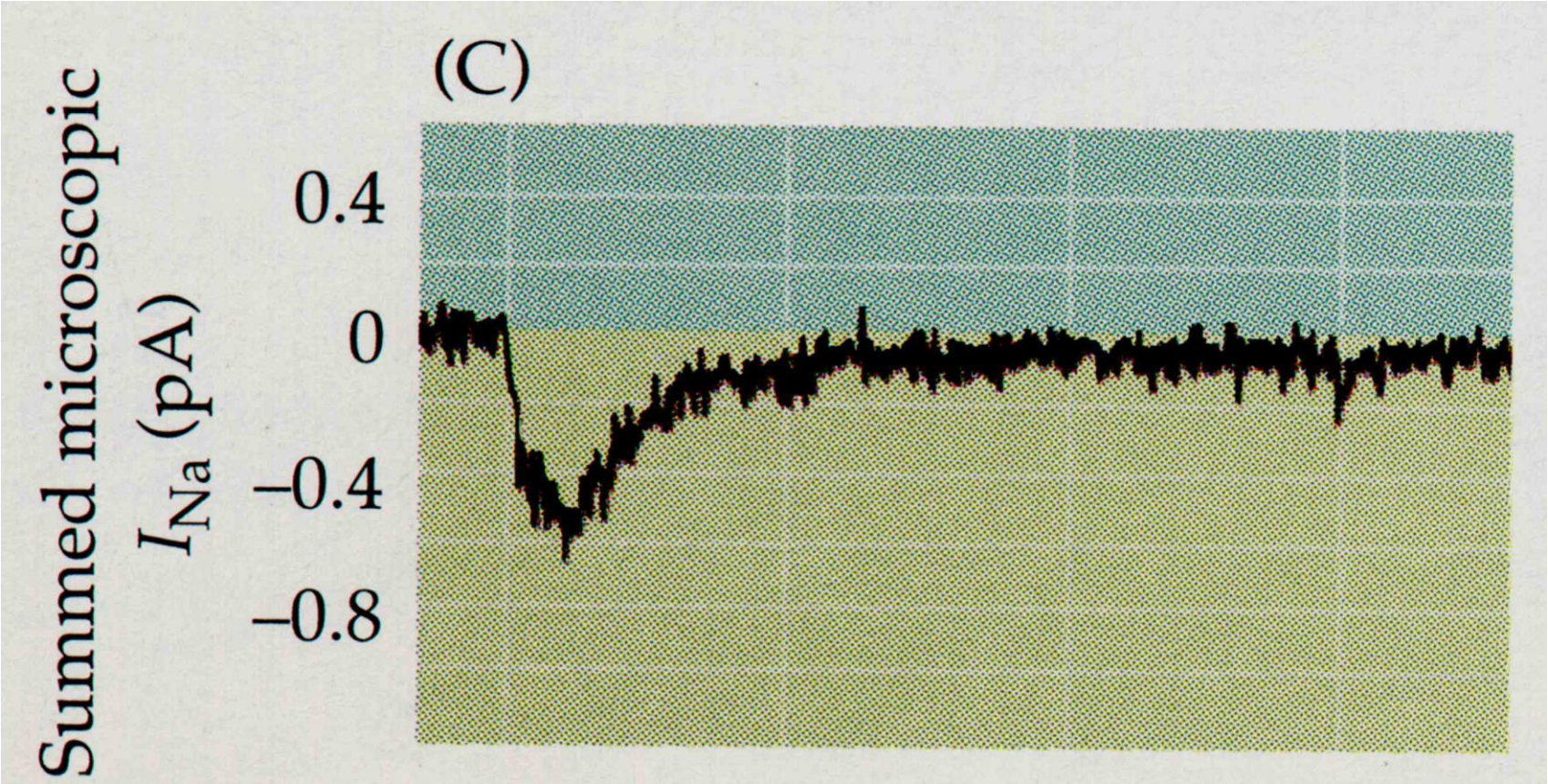
1 pA

50 ms

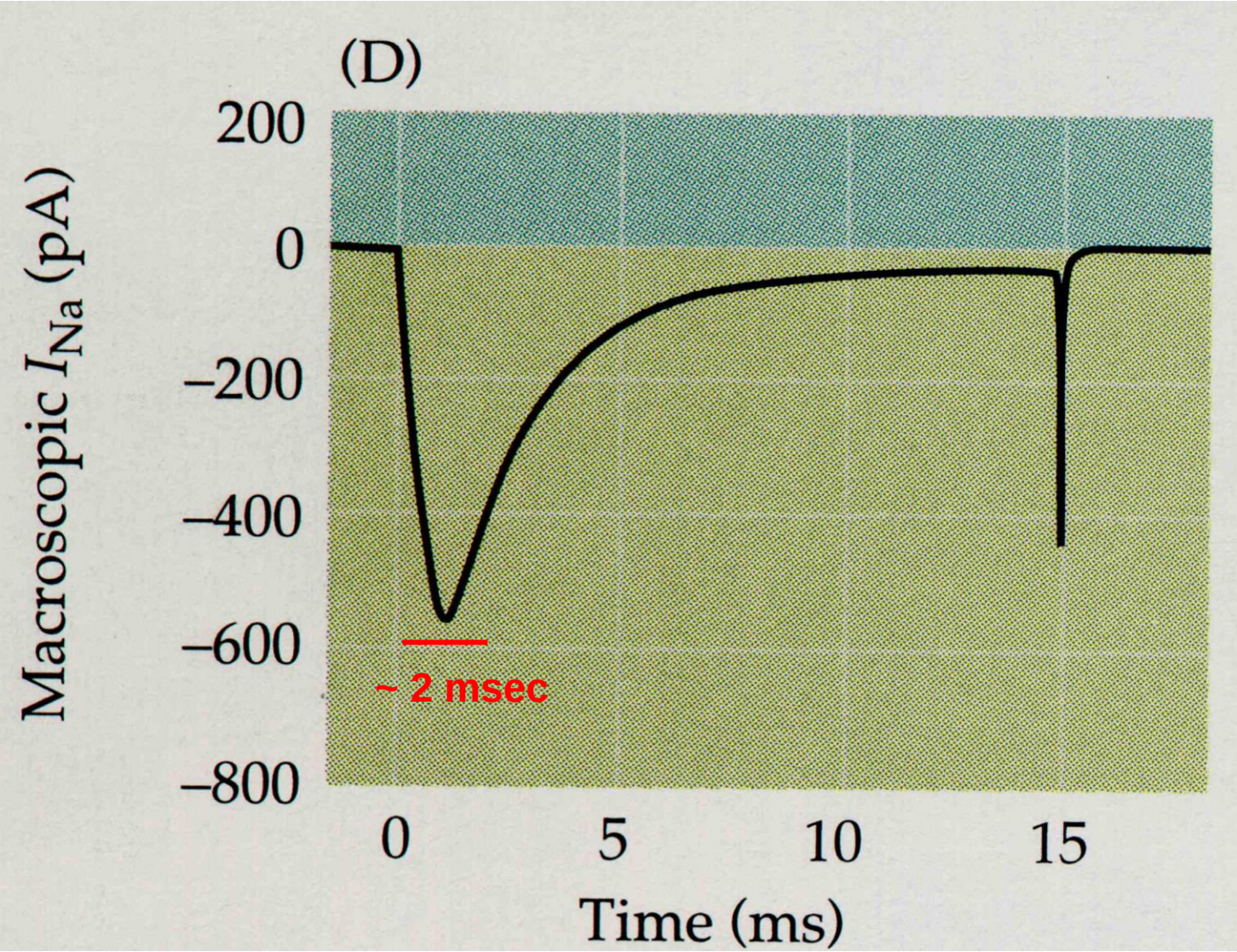
Natriumströme



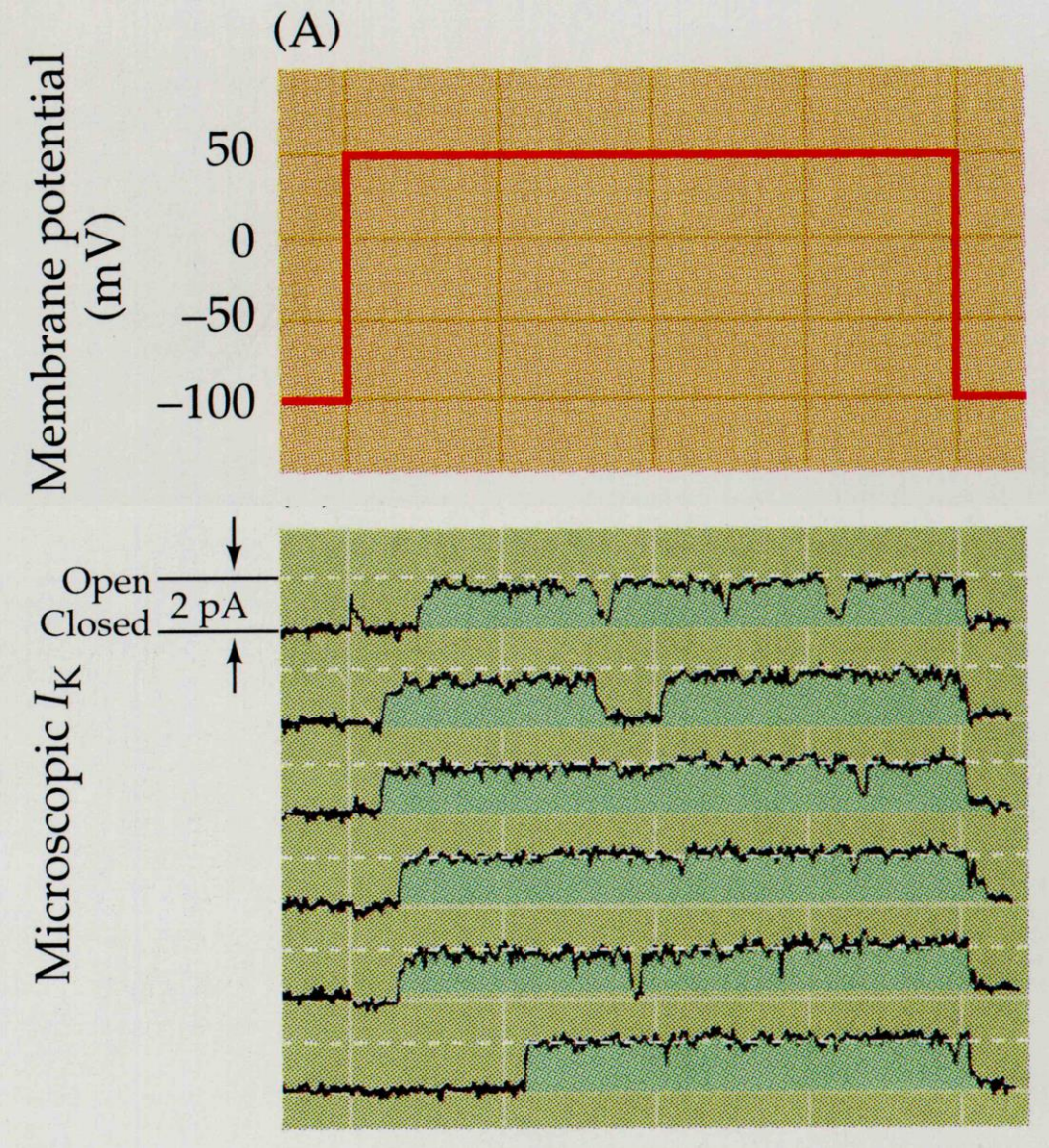
Natriumströme



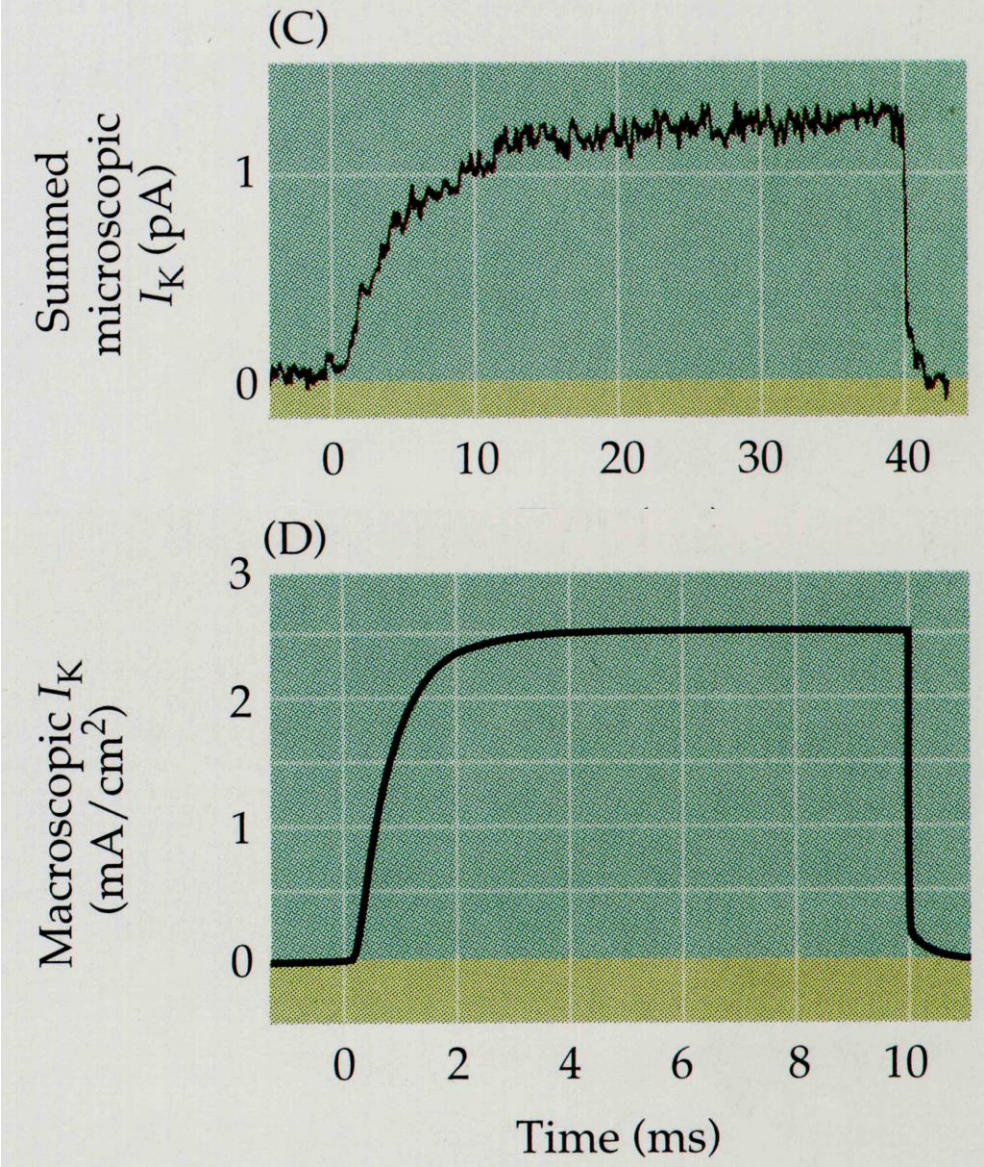
Natriumströme



Kaliumströme

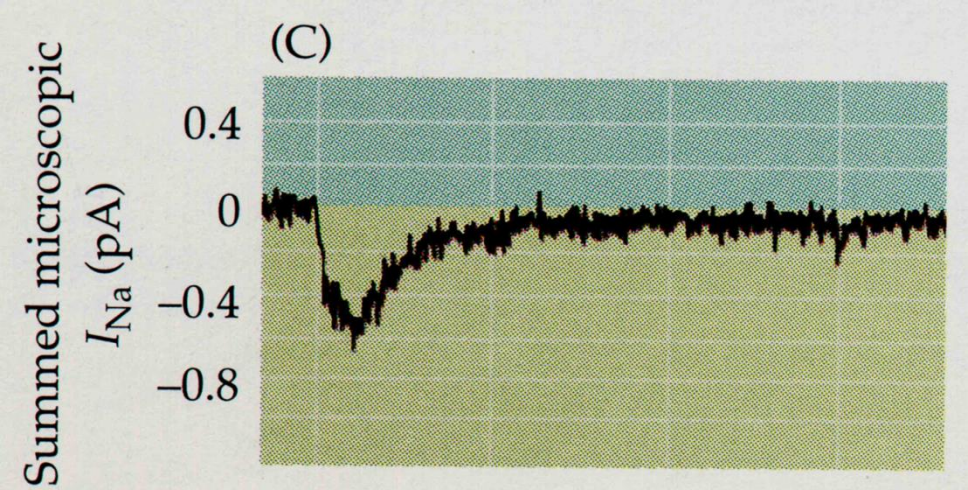


Kaliumströme

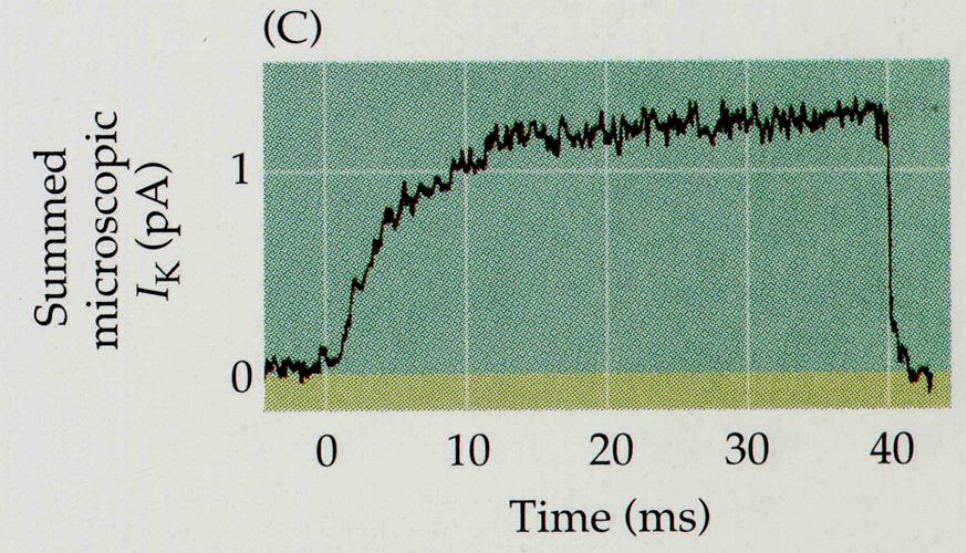


Vergleich der makroskopischen Na^+ und K^+ Ströme

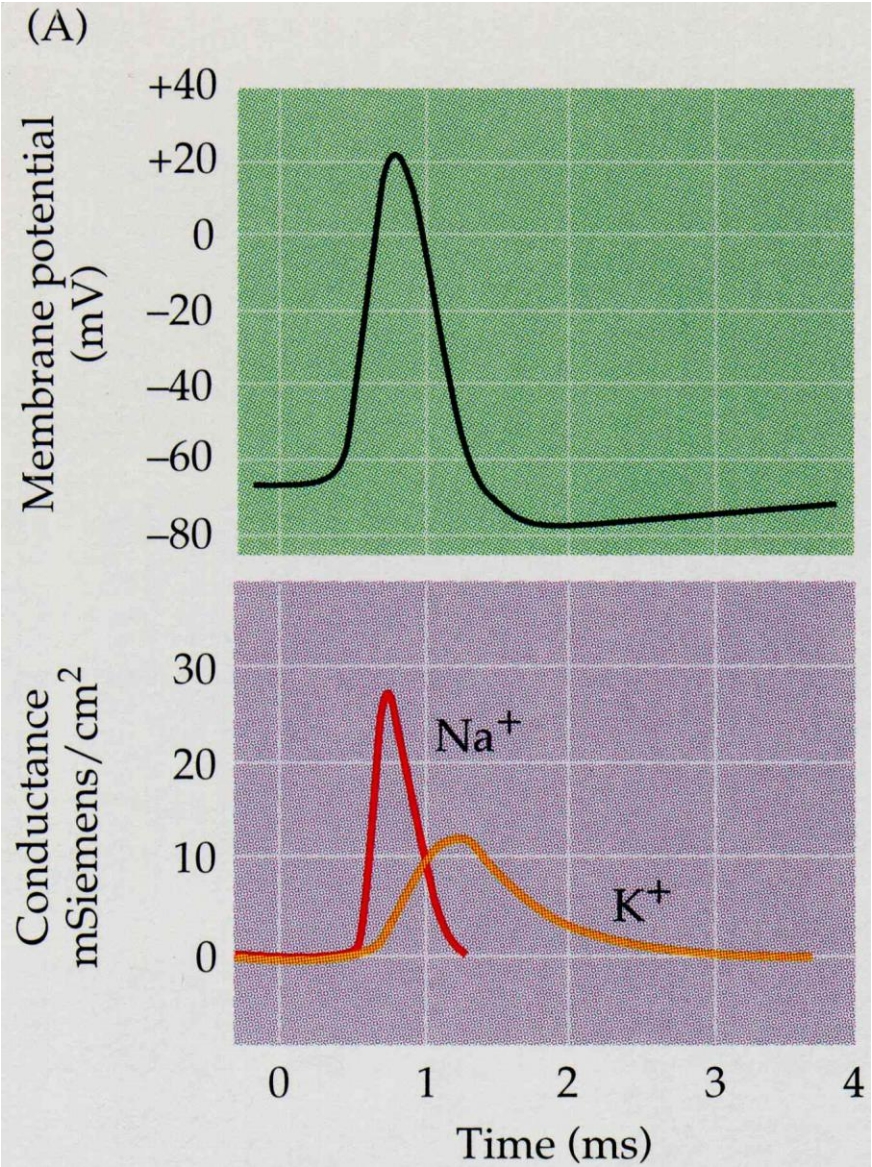
I_{Na}



I_K



Aktionspotenzial

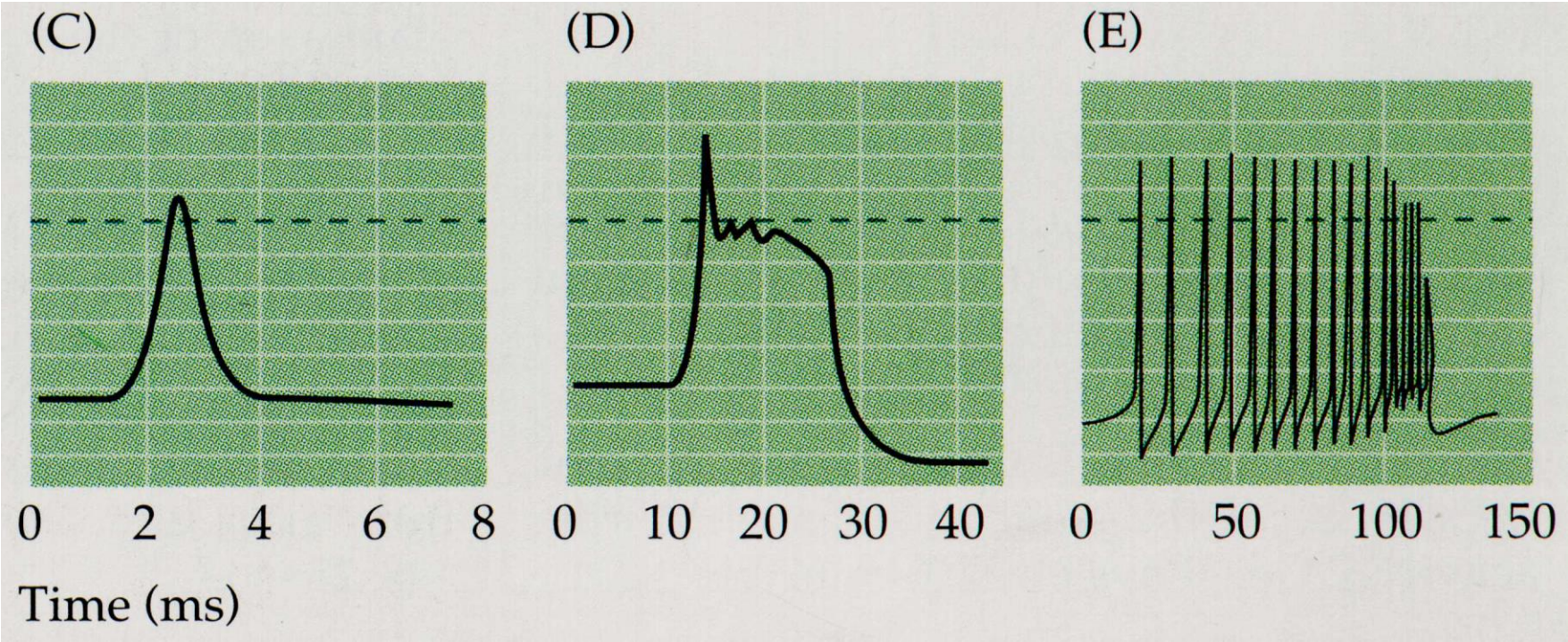


Aktionspotenzial “Verläufe“

Zellkörper eines Motorneurons (Frosch)

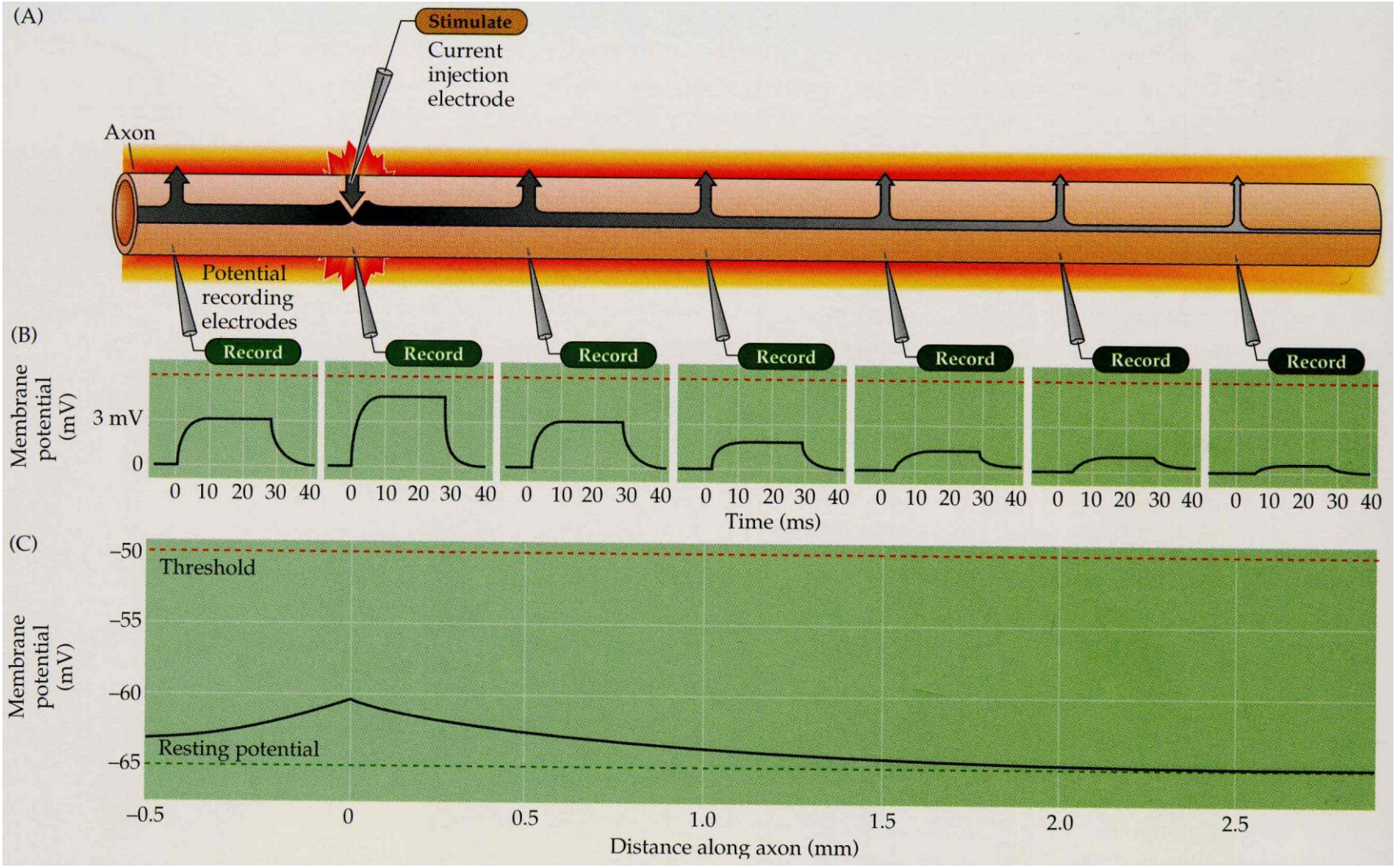
Zellkörper eines Neurons (inferior olive Meerschweinchen)

Zellkörper einer Purkinjezelle (Meer-Schweinchen)

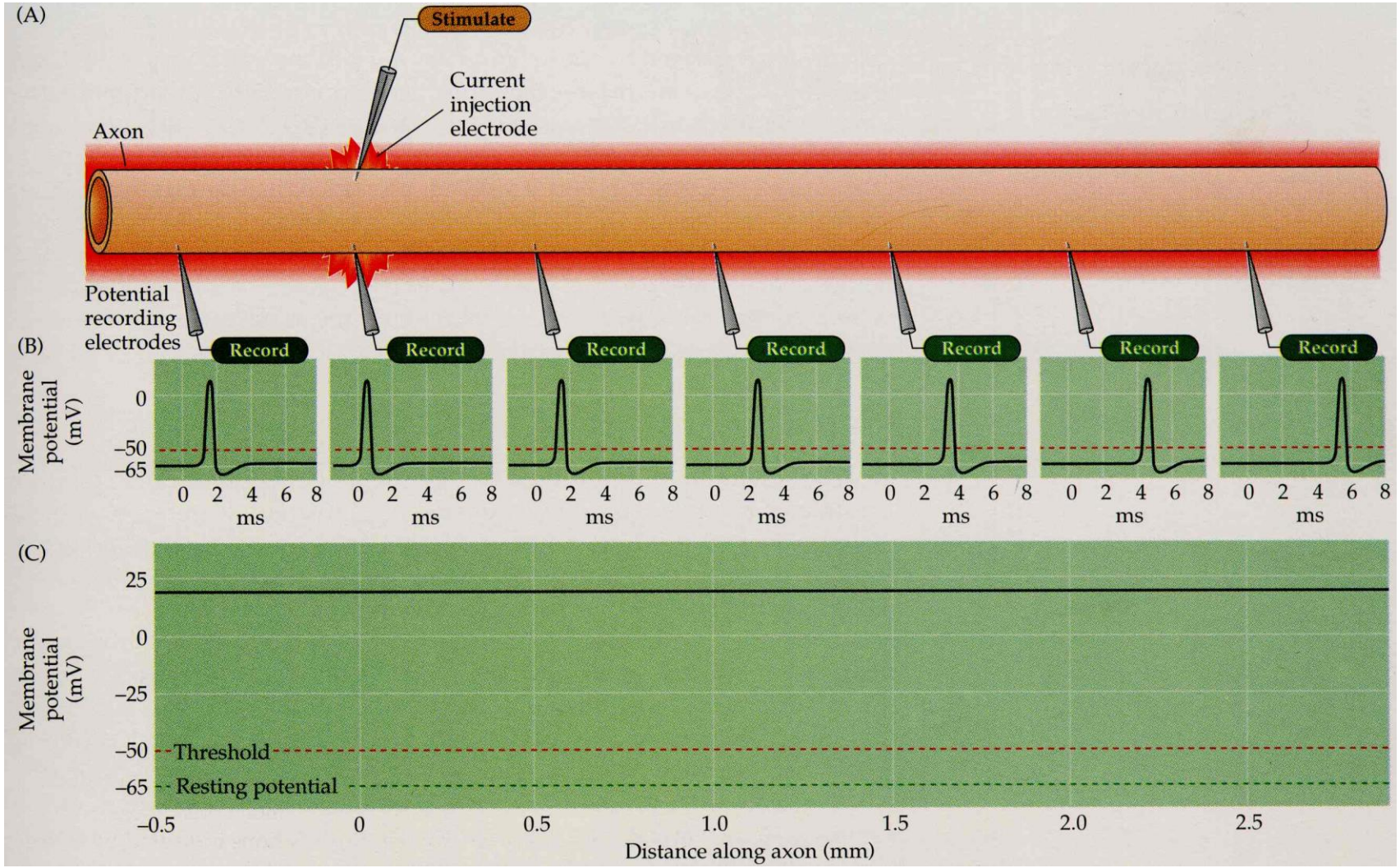


Weiterleitung des Aktionspotenzials

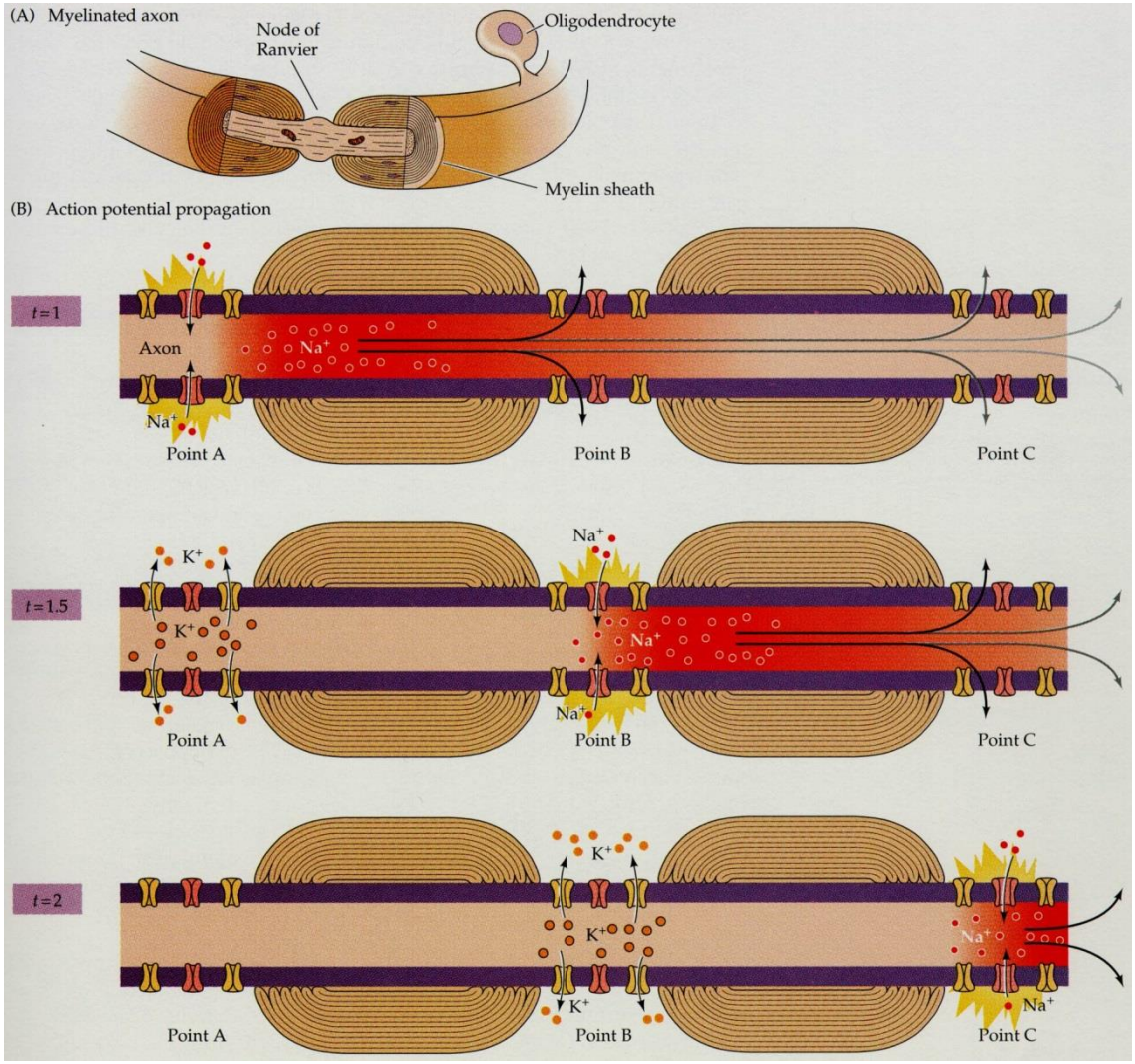
Nicht myelinisierte Axone



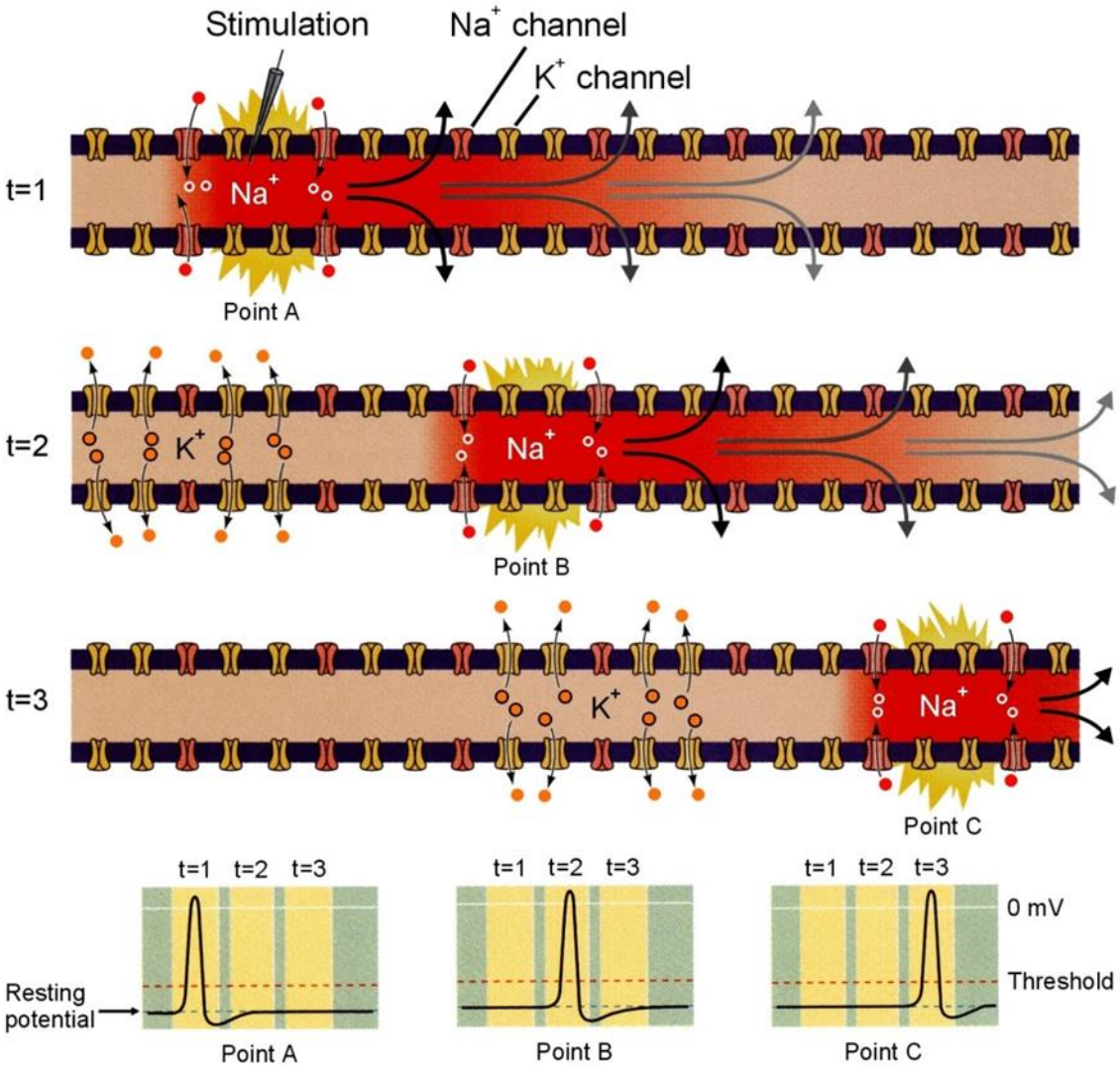
Myelinisierte Axone



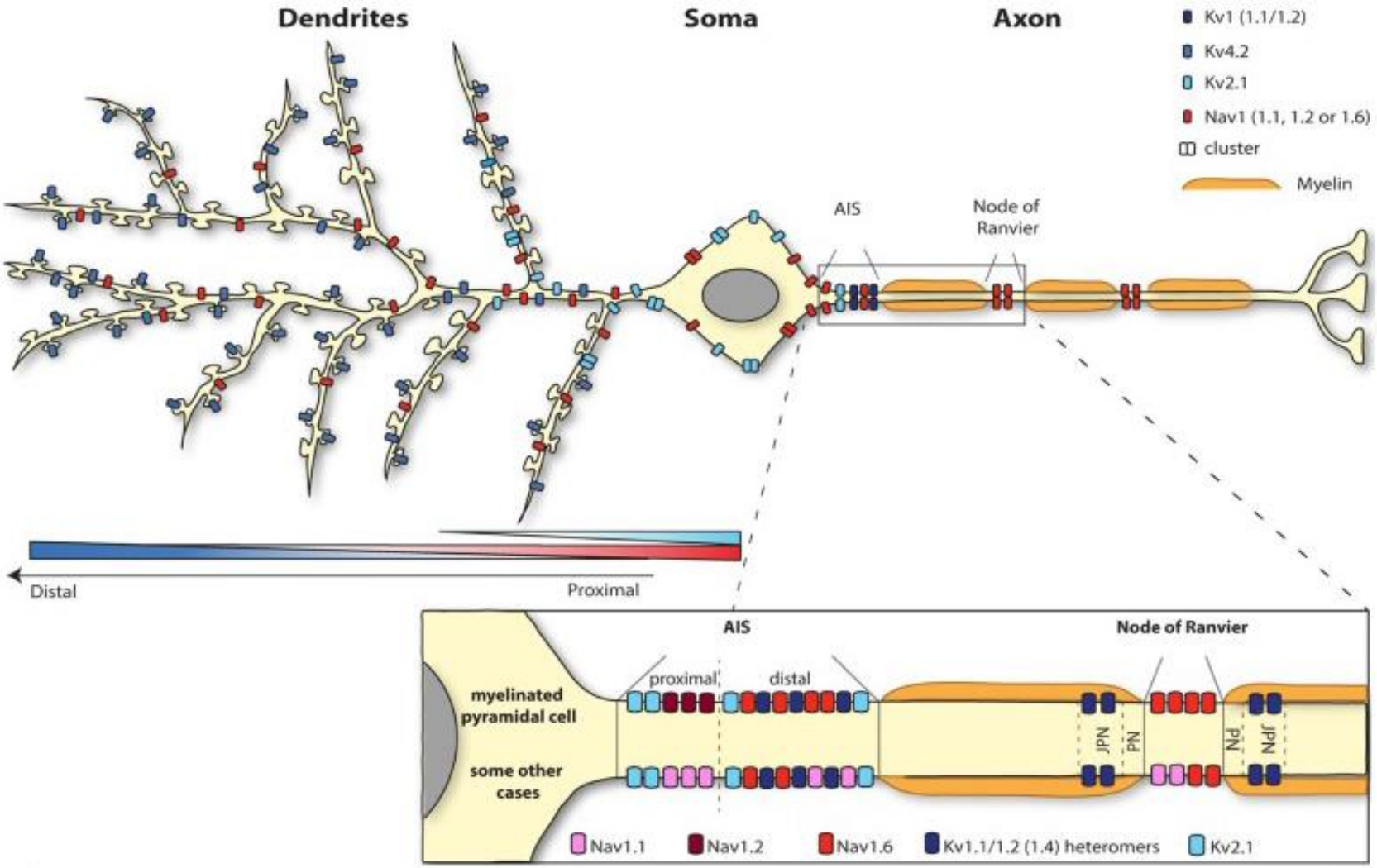
Myelinisierte Axone



Fortpflanzung Aktionspotenzial

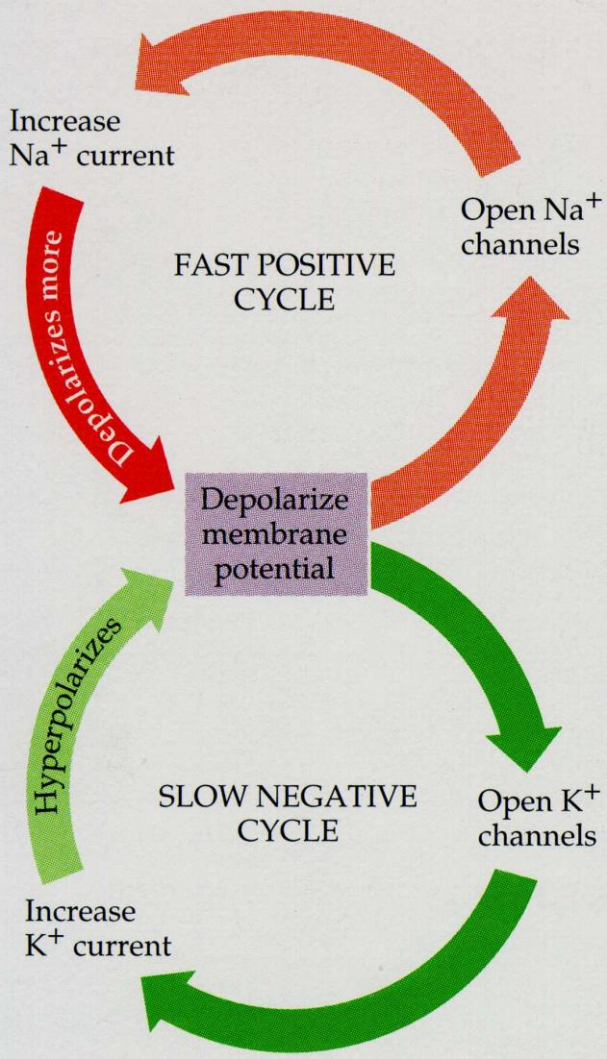
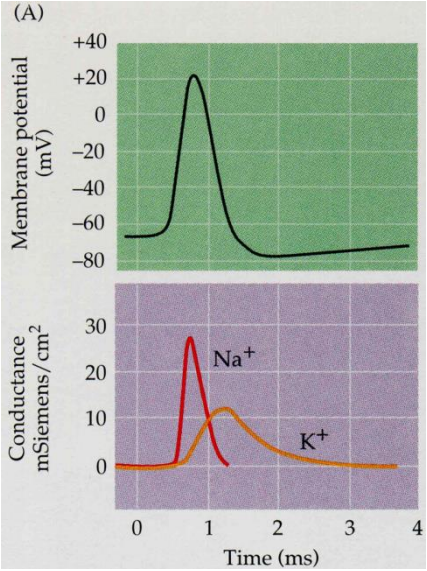
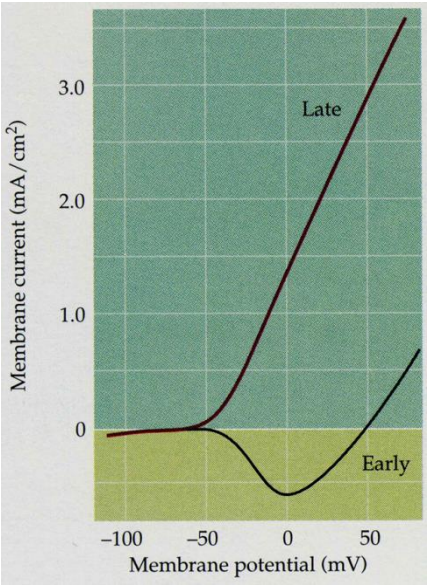
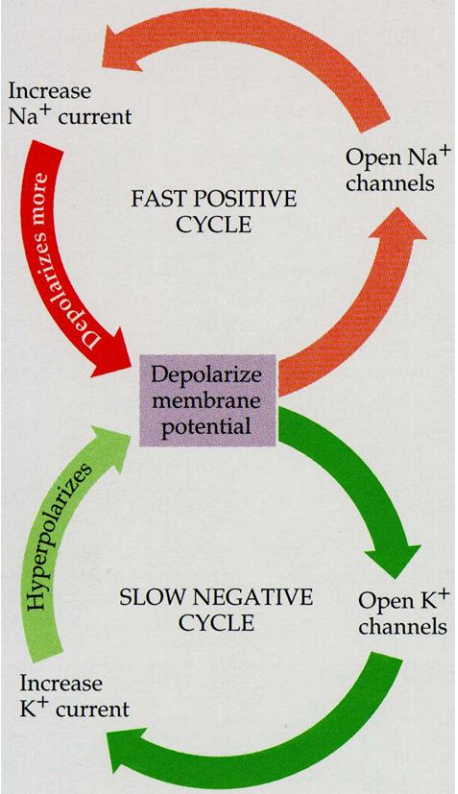
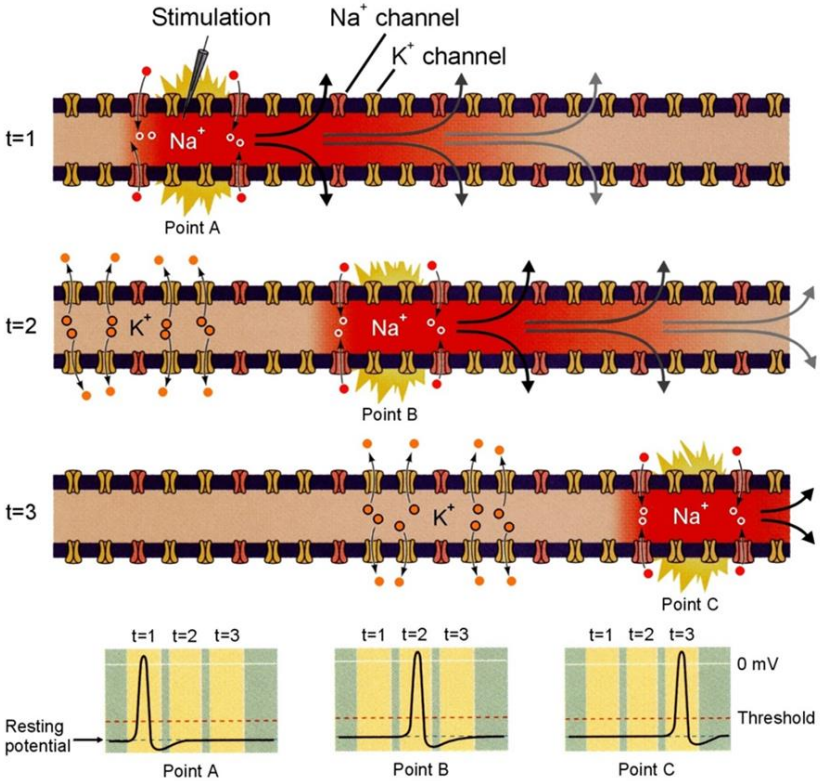


Fortpflanzung Aktionspotenzial - Kanalverteilung



Dumenieu, M.et al. (2017) Front. Cell. Neurosci. **11**, 115

Ionenbeiträge zum Aktionspotenzial



Zusammenfassung