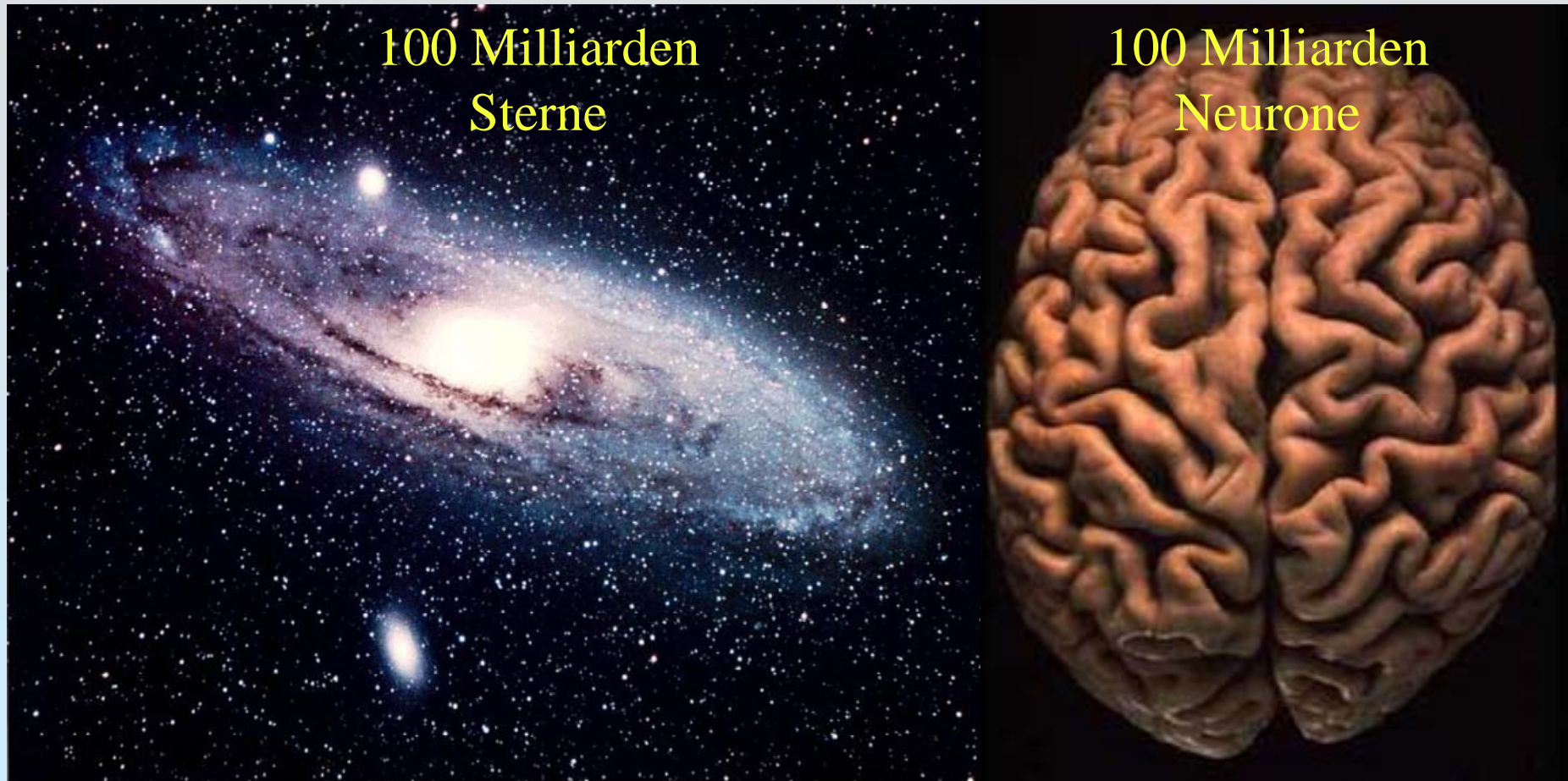


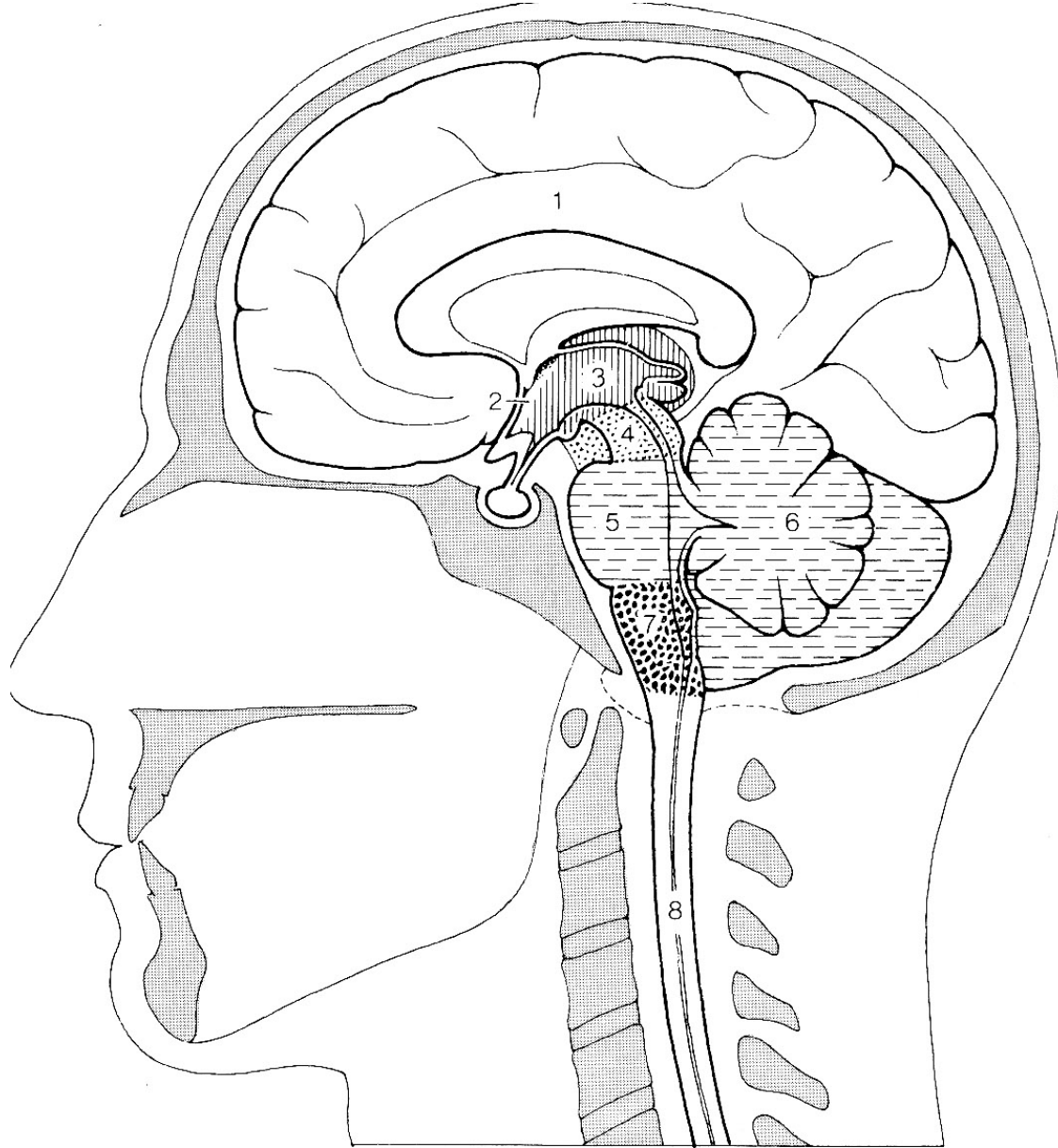
Die unermessliche Komplexität des Gehirns



100 Milliarden
Sterne

100 Milliarden
Neurone

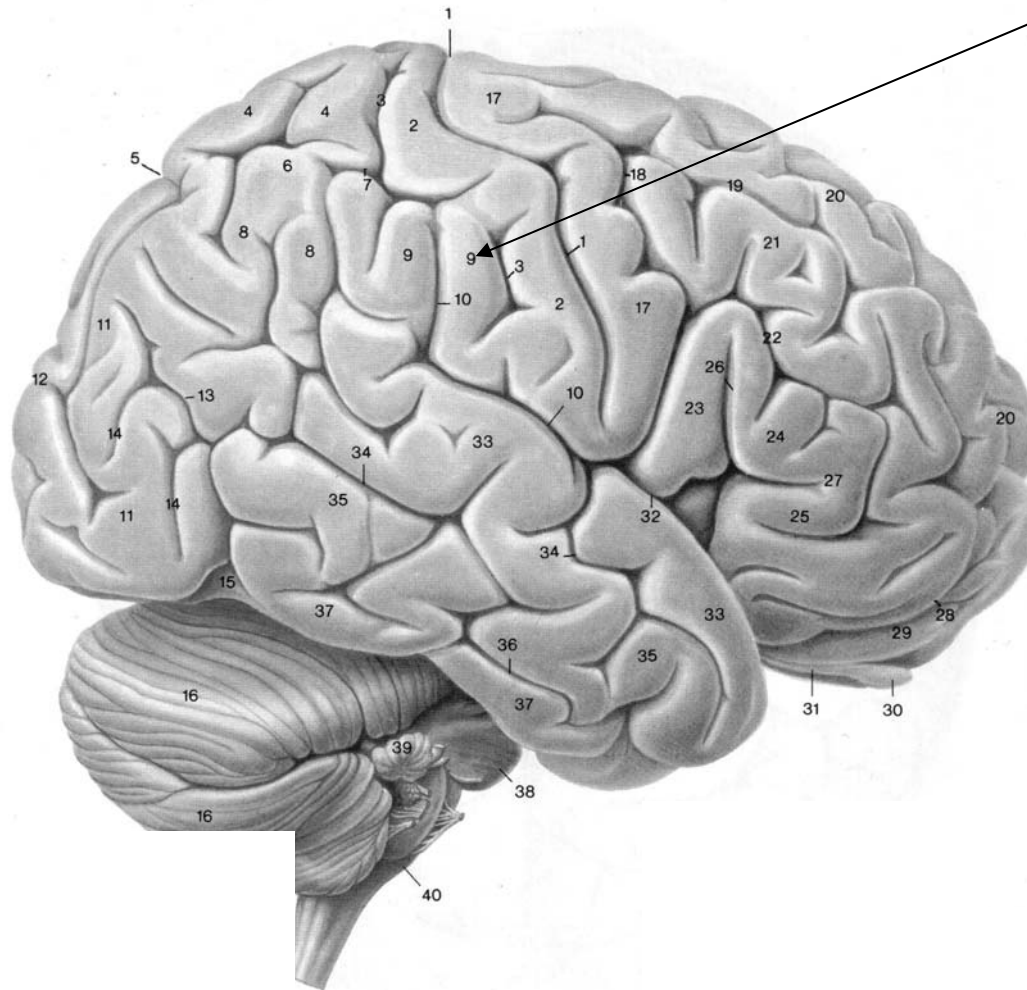
**Definition: Komplexität entsteht aus der Vielfalt
der Beziehungen der Elemente eines Systems**



1 Telencephalon (Cerebrum)	Prosencephalon	Encephalon Neuraxis (Systema nervosum centrale)	
2 Telencephalon impar			
3 Diencephalon			
4 Mesencephalon	Rhombencephalon		
5 Pons } 6 Cerebellum }			Metencephalon
7 Myelencephalon (Medulla oblongata)			
8 Medulla spinalis	Truncus cerebri		

Nieuwenhuys et al. (1991)
 Das Zentralnervensystem
 des Menschen

Großhirnrinde des Menschen



1 Modul

ca. 5000 Nervenzellen

bei 10 Millionen Modulen
in der Großhirnrinde

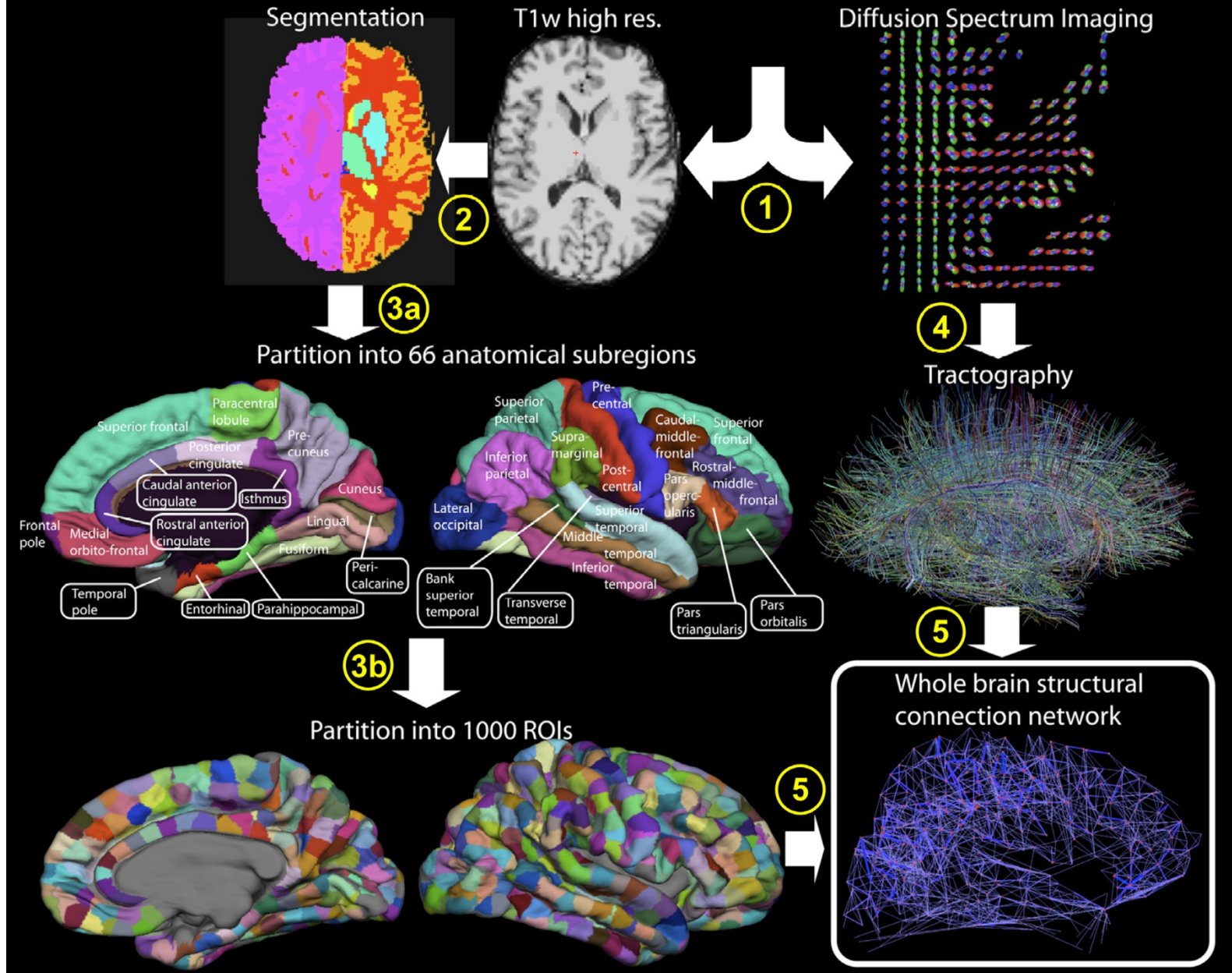
ca. 50 Milliarden Nervenzellen

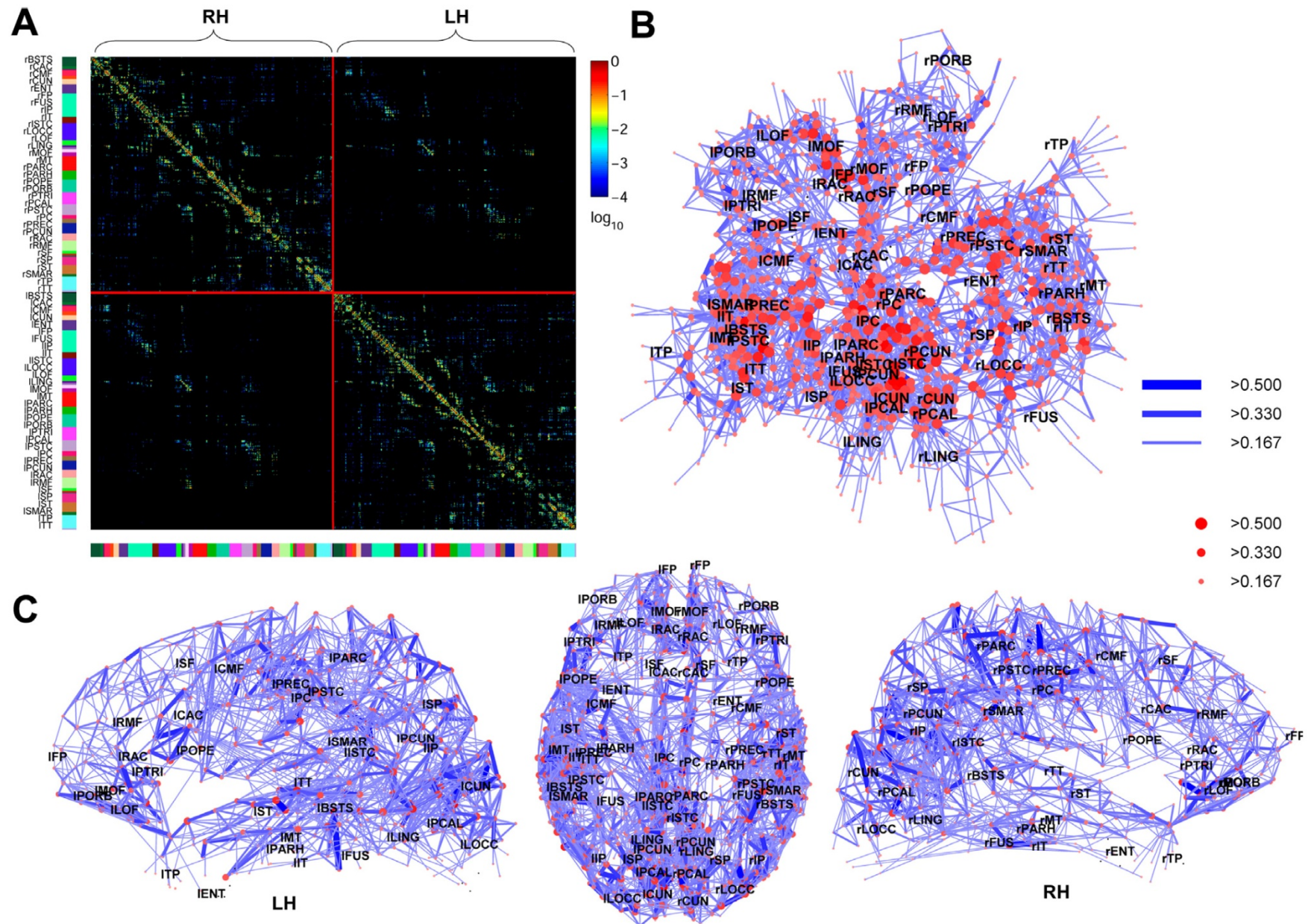
bei 3000 Kontaktstellen
pro Nervenzelle

150 000 000 000 000
= 150 Billionen Kontakte
alleine in der
Großhirnrinde des Menschen

Nieuwenhuys et al. (1991)
Das Zentralnervensystem
des Menschen

MRI Acquisition

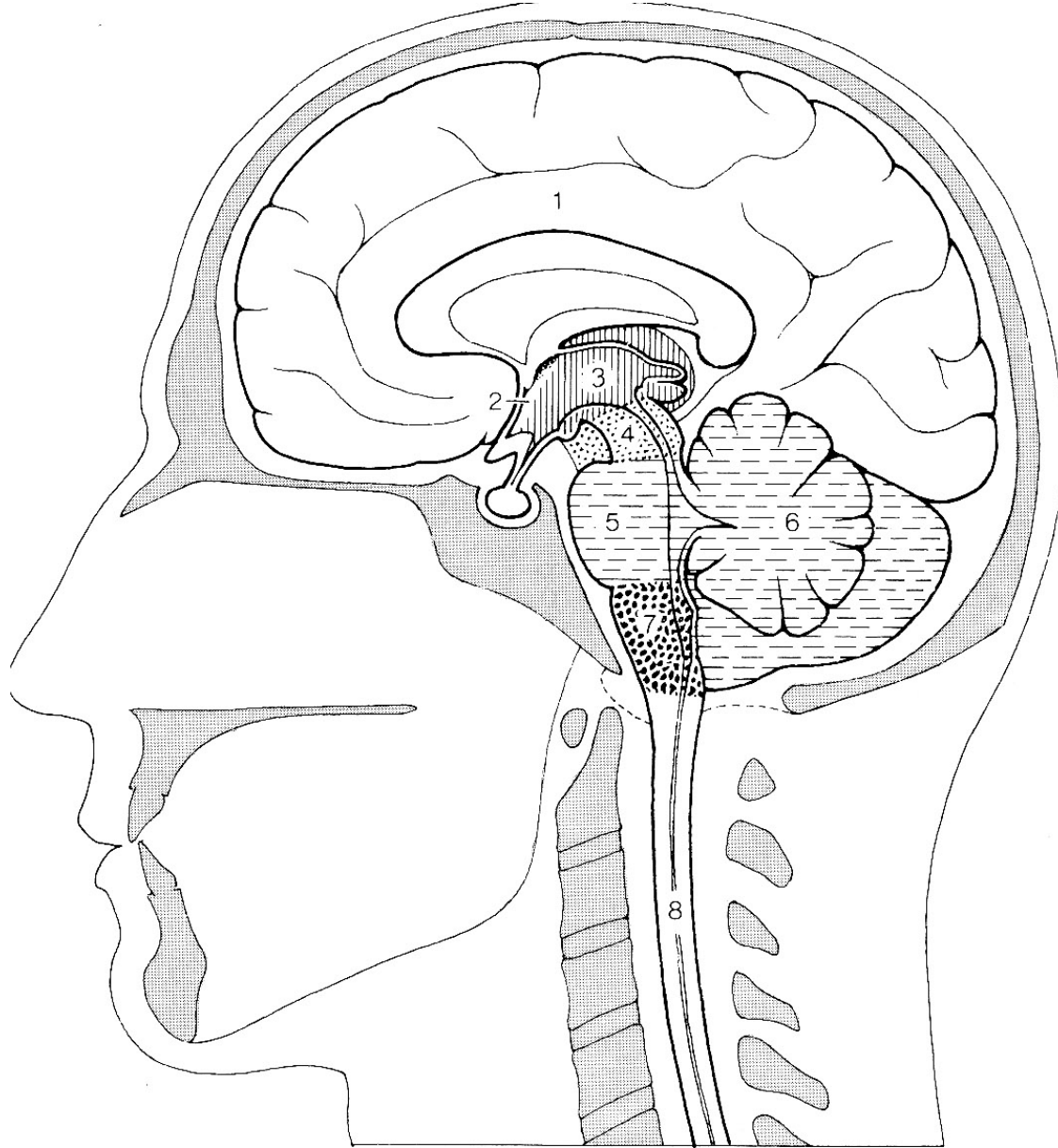




Gehirnzentren und Verbindungsbahnen für visuelle Wahrnehmung



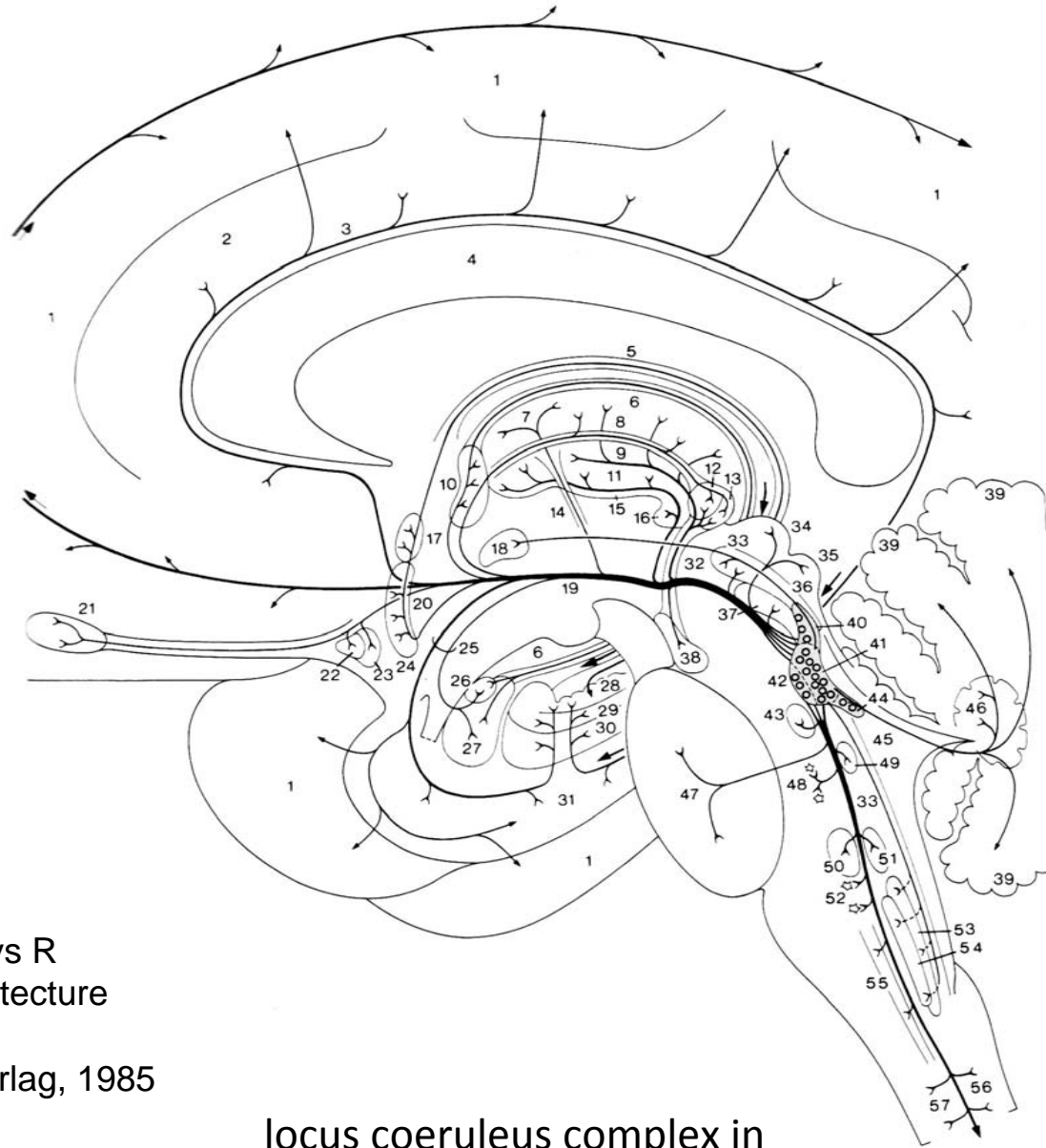
Van Essen DC, DeYoe EA
(1995) In: The Cognitive
Neurosciences



1 Telencephalon (Cerebrum)	Prosencephalon	Encephalon Neuraxis (Systema nervosum centrale)	
2 Telencephalon impar			
3 Diencephalon			
4 Mesencephalon	Rhombencephalon		
5 Pons } 6 Cerebellum }			Metencephalon
7 Myelencephalon (Medulla oblongata)			
8 Medulla spinalis	Truncus cerebri		

Nieuwenhuys et al. (1991)
 Das Zentralnervensystem
 des Menschen

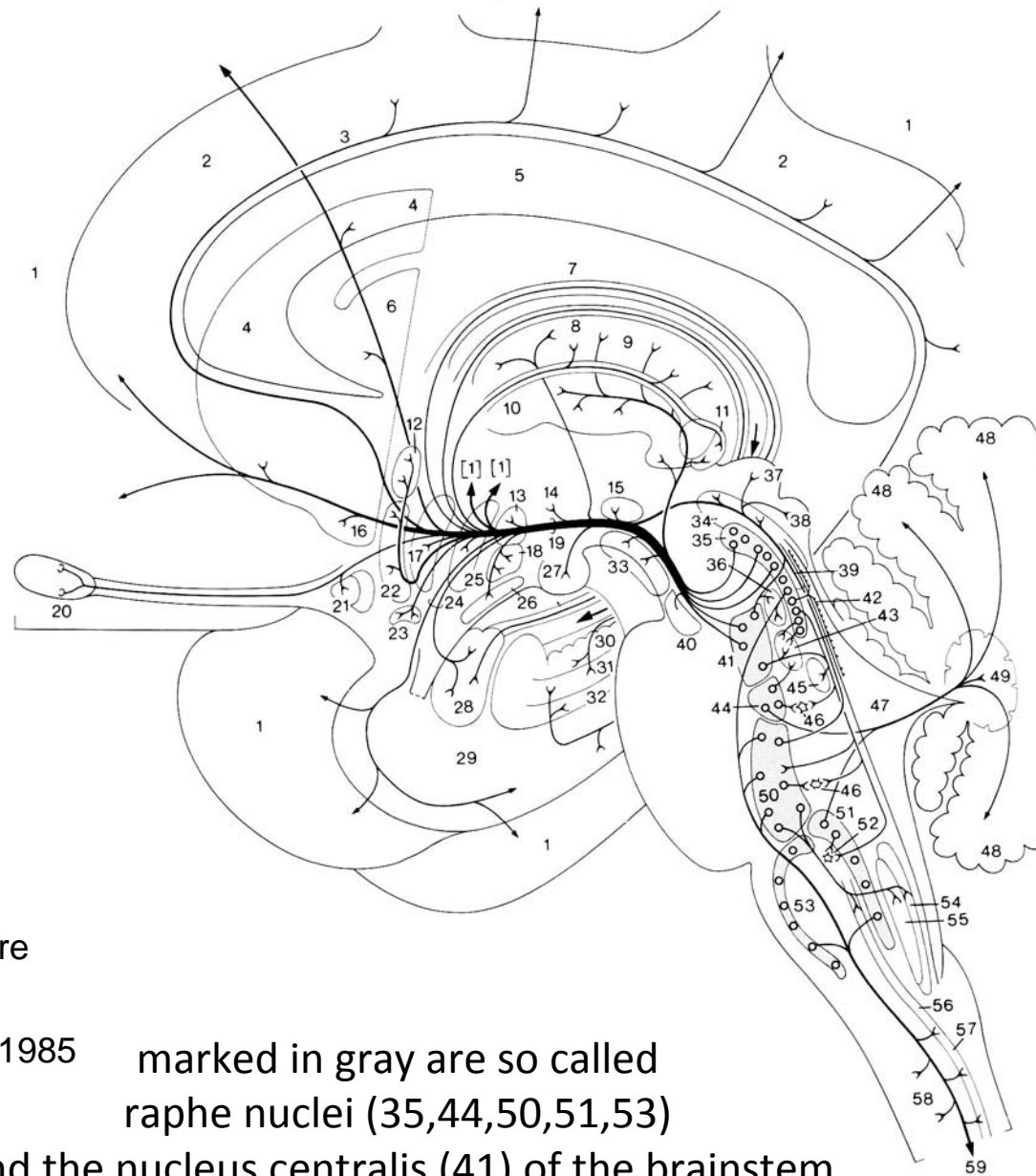
Noradrenaline-containing cells and fibres



Nieuwenhuys R
Chemoarchitecture
of the Brain
Springer-Verlag, 1985

locus coeruleus complex in
tegmentum: areas 40, 41, 42

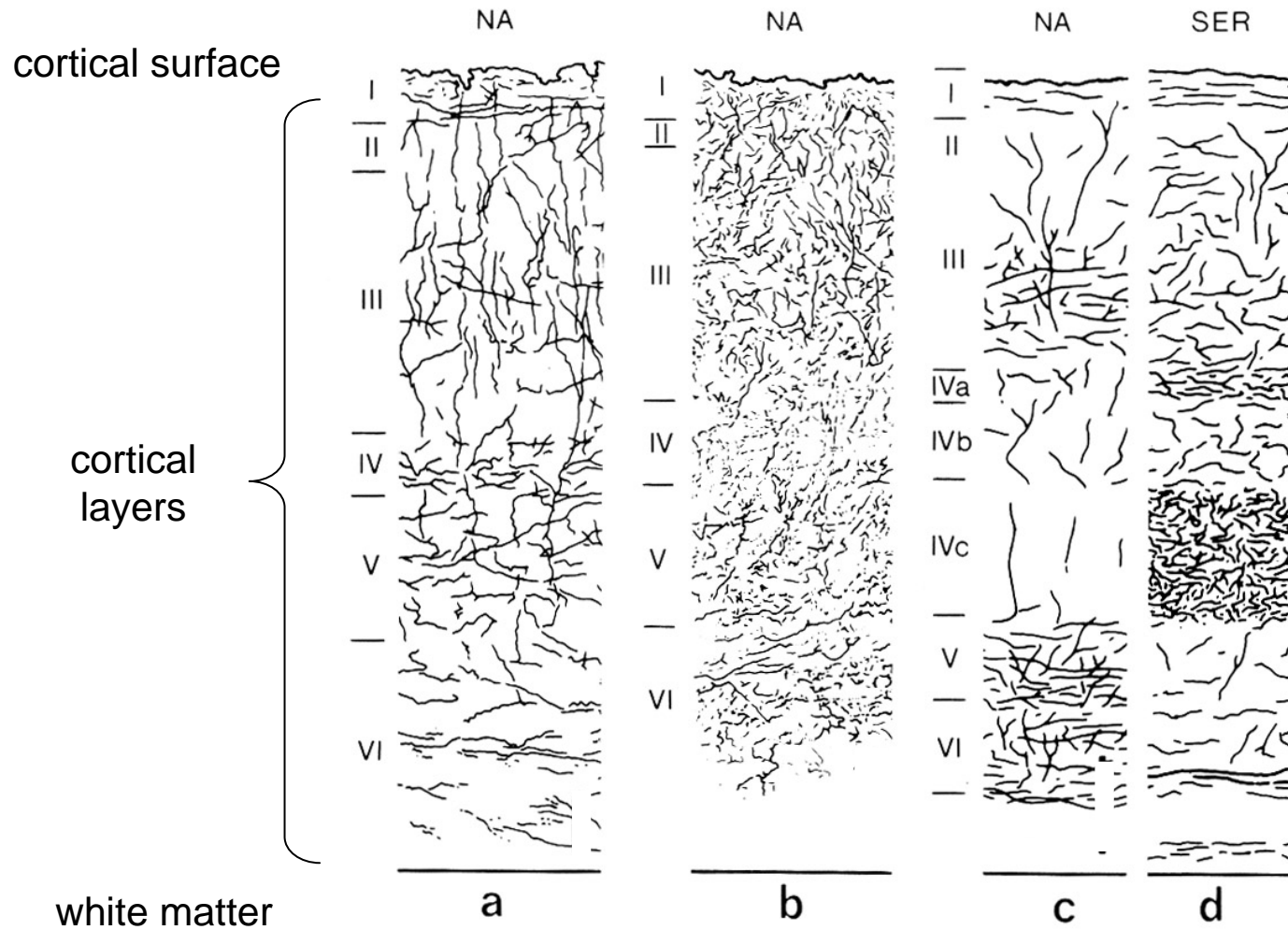
Serotonin-containing cells and fibres



Nieuwenhuys R
Chemoarchitecture
of the Brain
Springer-Verlag, 1985

marked in gray are so called
raphe nuclei (35,44,50,51,53)
and the nucleus centralis (41) of the brainstem

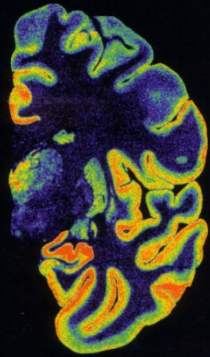
squirrel monkey neocortex:
examples of noradrenergic and serotonergic innervation



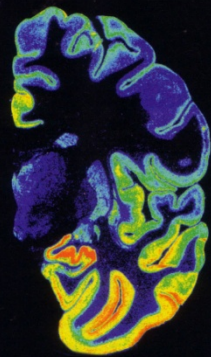
Nieuwenhuys R
Chemoarchitecture
of the Brain
Springer-Verlag, 1985

(a) prefrontal cortex, (b) primary somatosensory cortex, (c, d) primary visual cortex

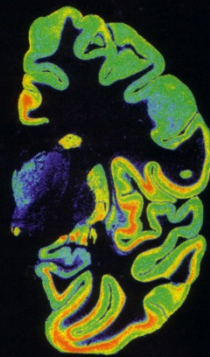
NMDA (Glutamat)



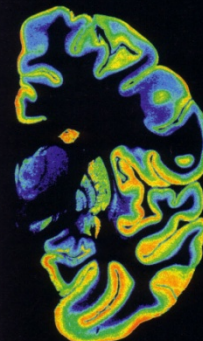
AMPA (Glutamat)



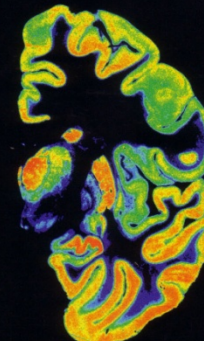
Kainat (Glutamat)



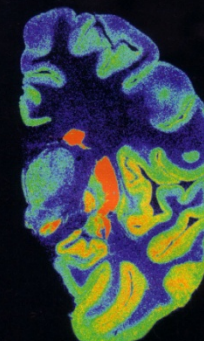
mGlu2/3 (Glutamat)



A₁ (Adenosin)



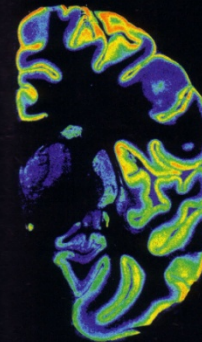
D₁ (Dopamin)



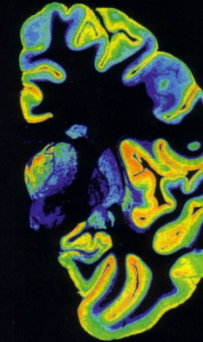
Verteilung von Rezeptoren
von Neurotransmittern und
Neuromodulatoren

Zilles und Amunts 2010, Gehirn und Geist

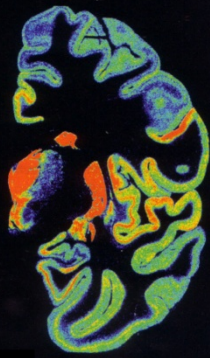
GABA_A (GABA)



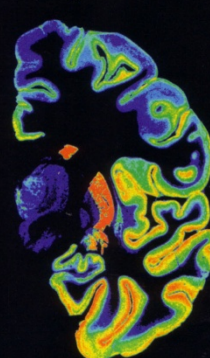
GABA_B (GABA)



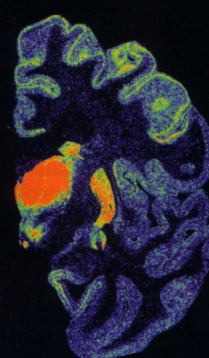
M₂ (Azetylcholin)



M₃ (Azetylcholin)



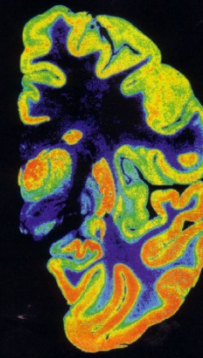
nikotinisch (Azetylcholin)



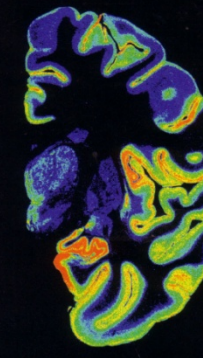
5-HT_{1A} (Serotonin)



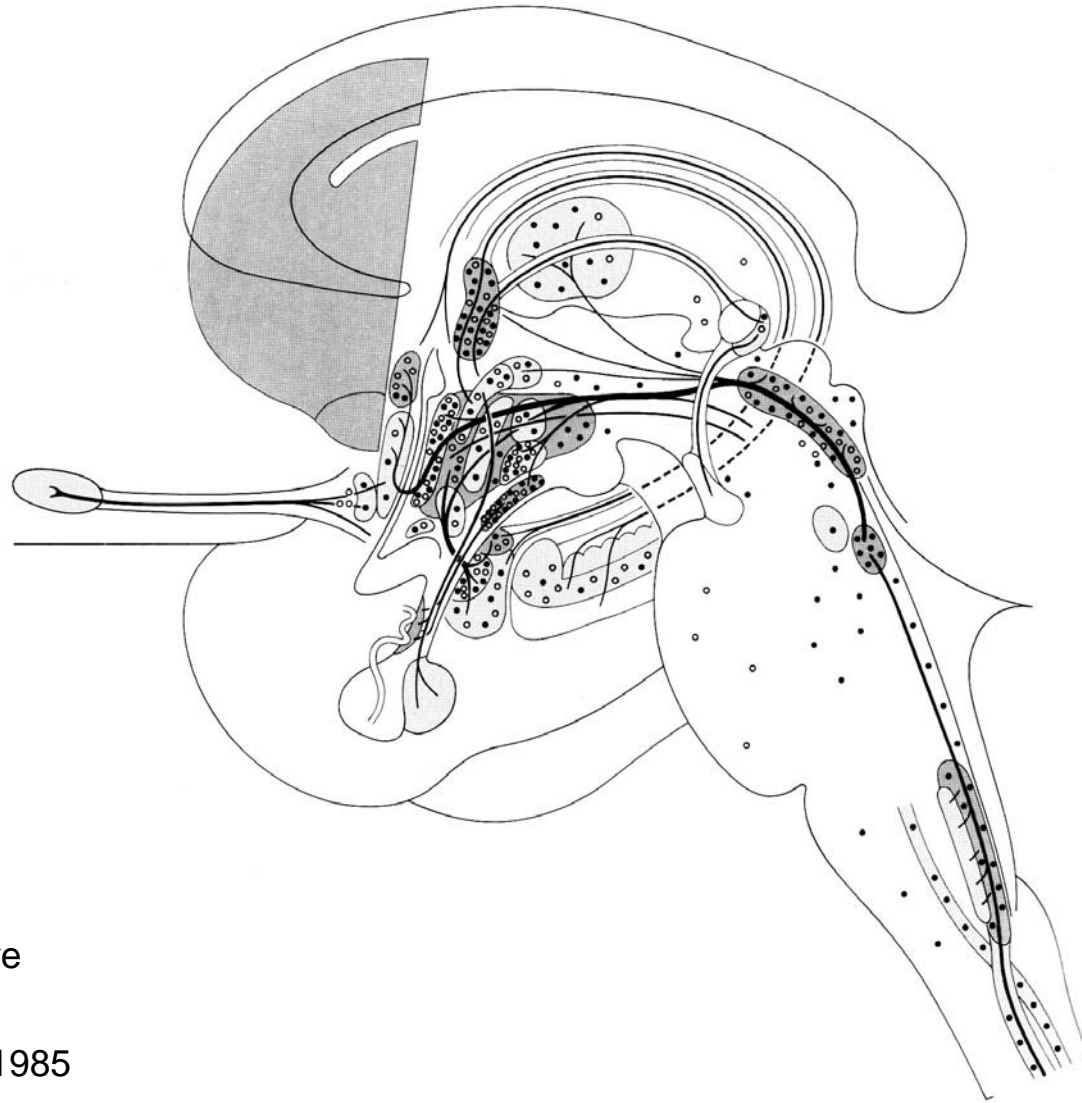
α₁ (Noradrenalin)



α₂ (Noradrenalin)



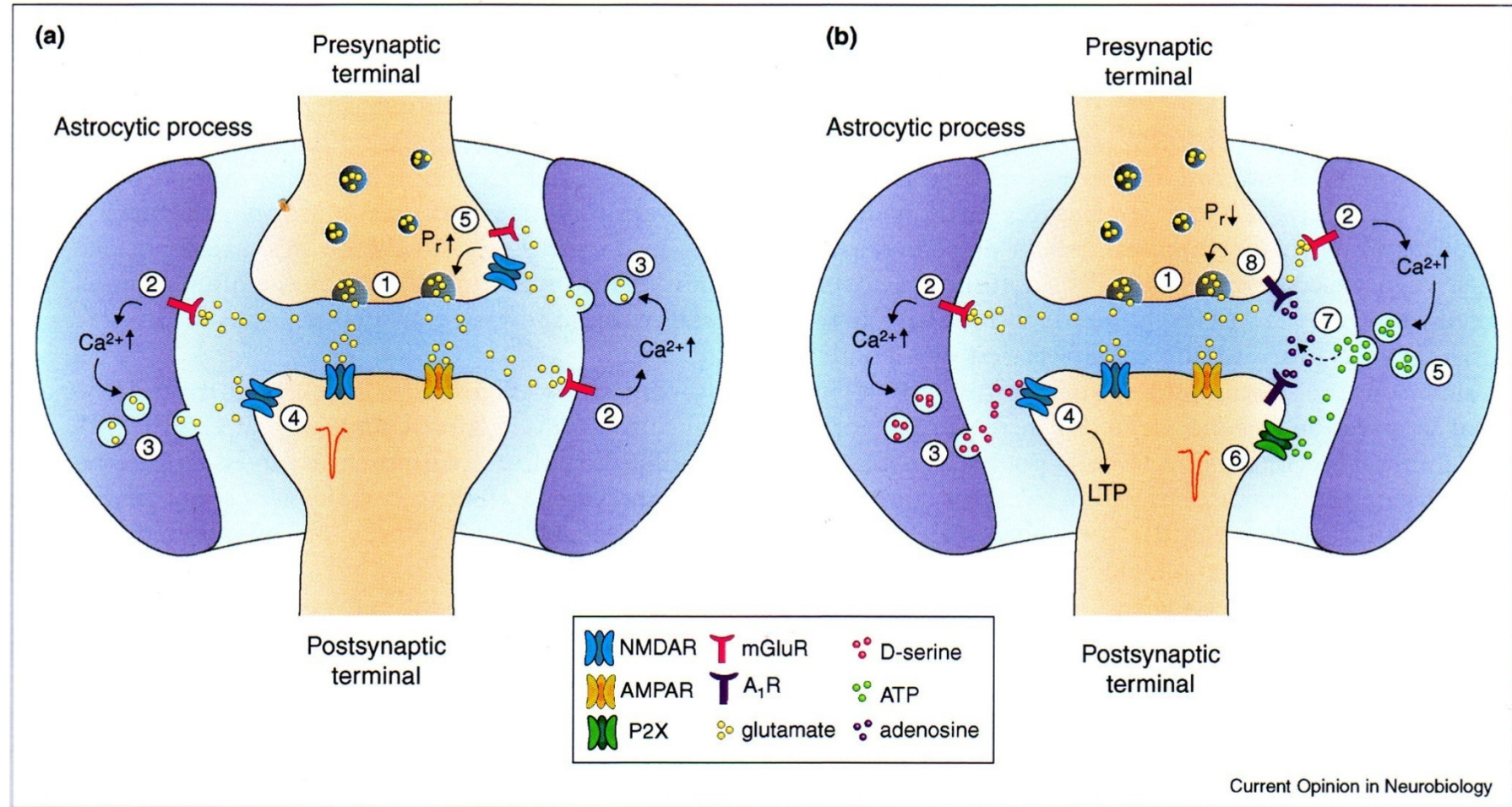
Estrogen and testosterone concentrating cells



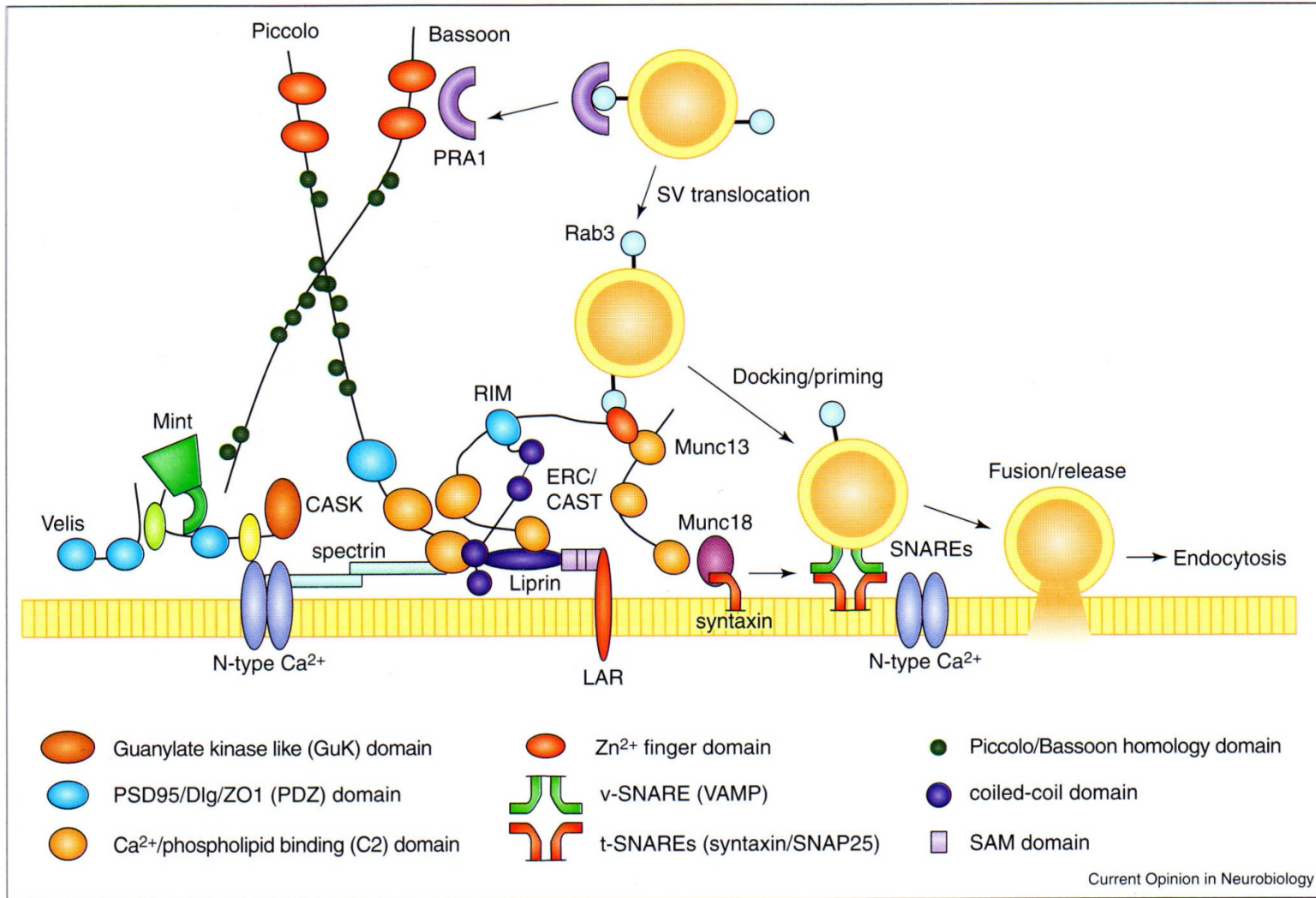
Nieuwenhuys R
Chemoarchitecture
of the Brain
Springer-Verlag, 1985

estrogen: dots; testosterone: circles

Komplexität synaptischer Informationsübertragung

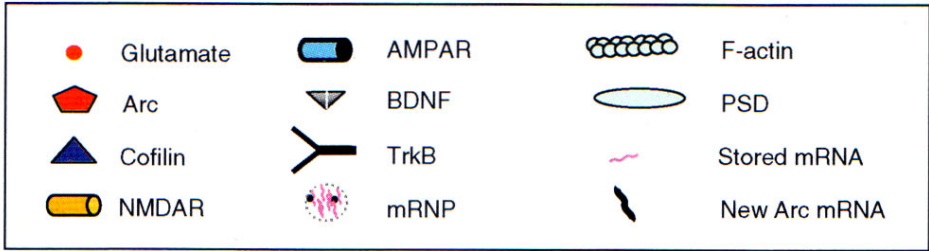
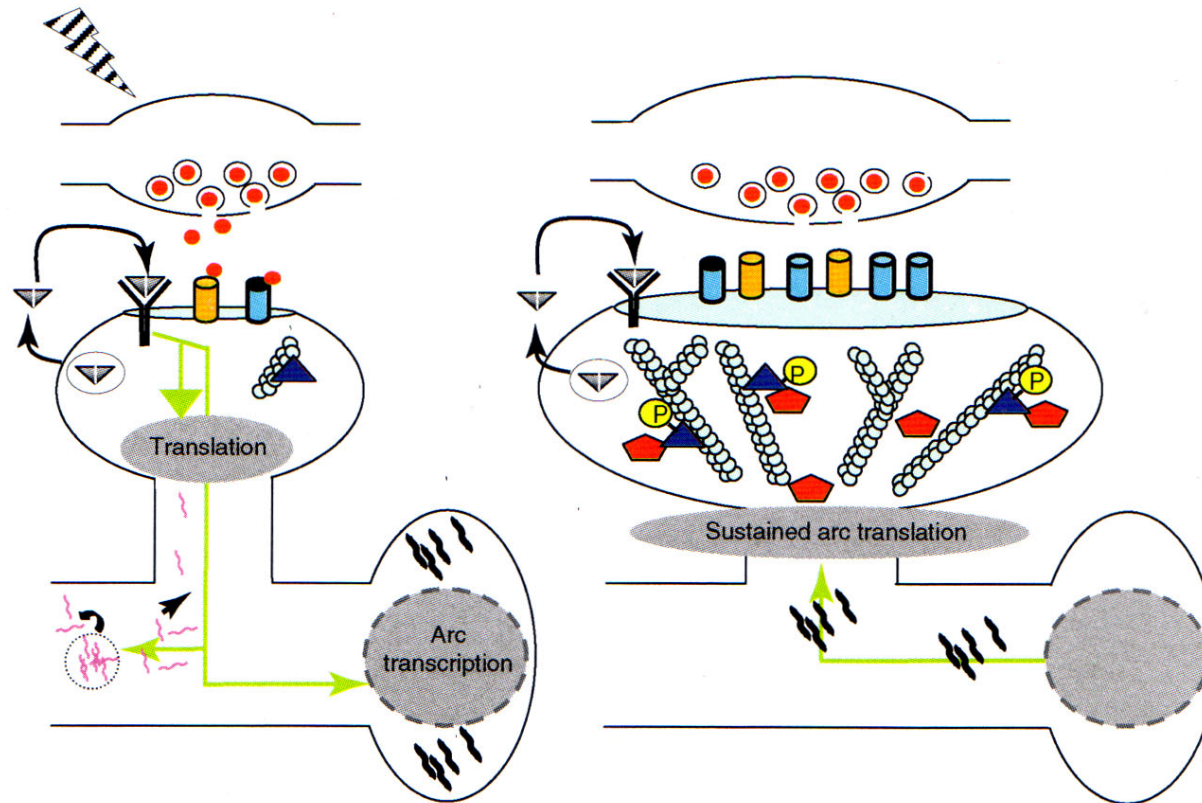


Komplexität der Neurotransmitterausschüttung

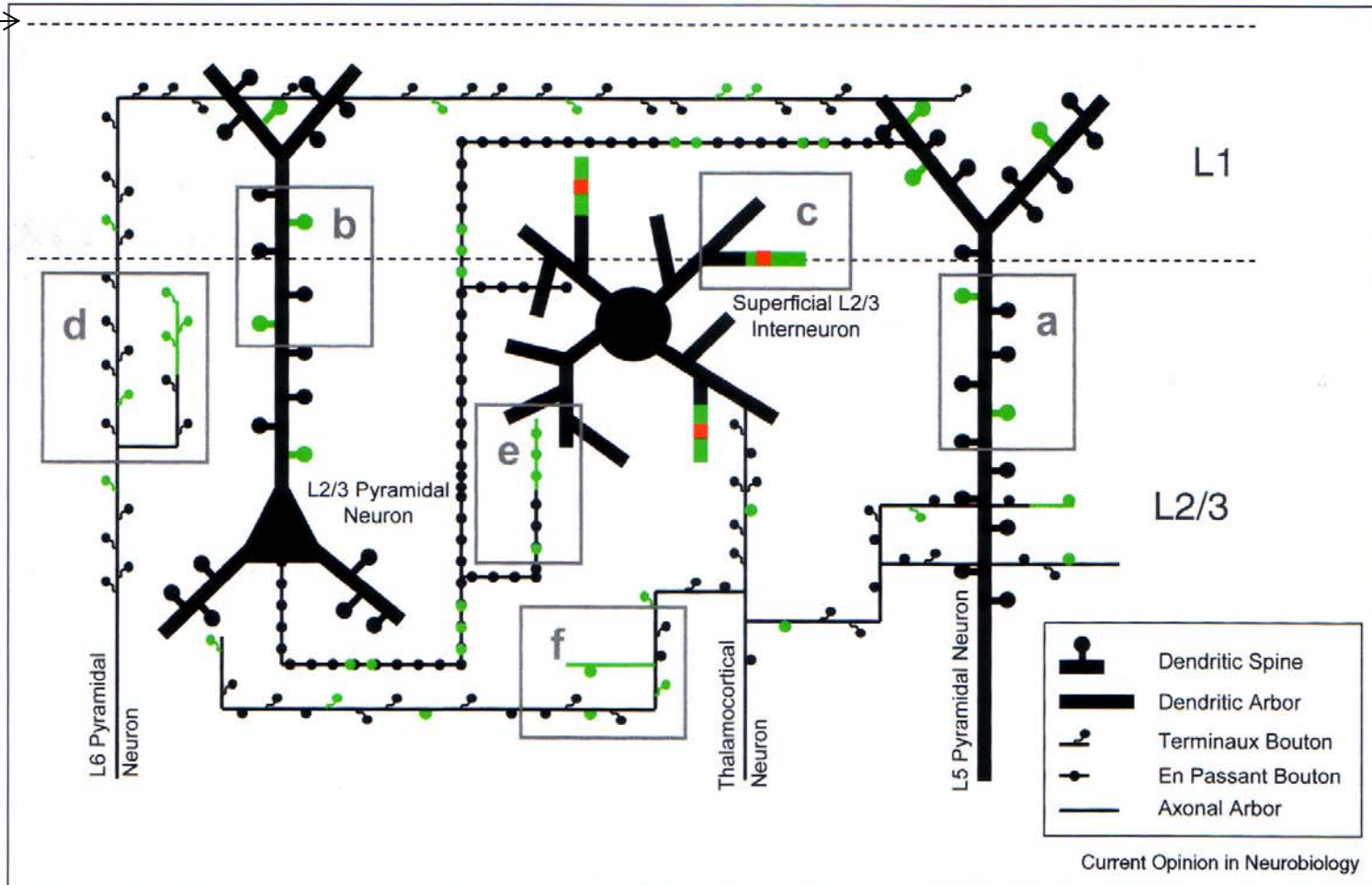


1. Translation activation and transcription

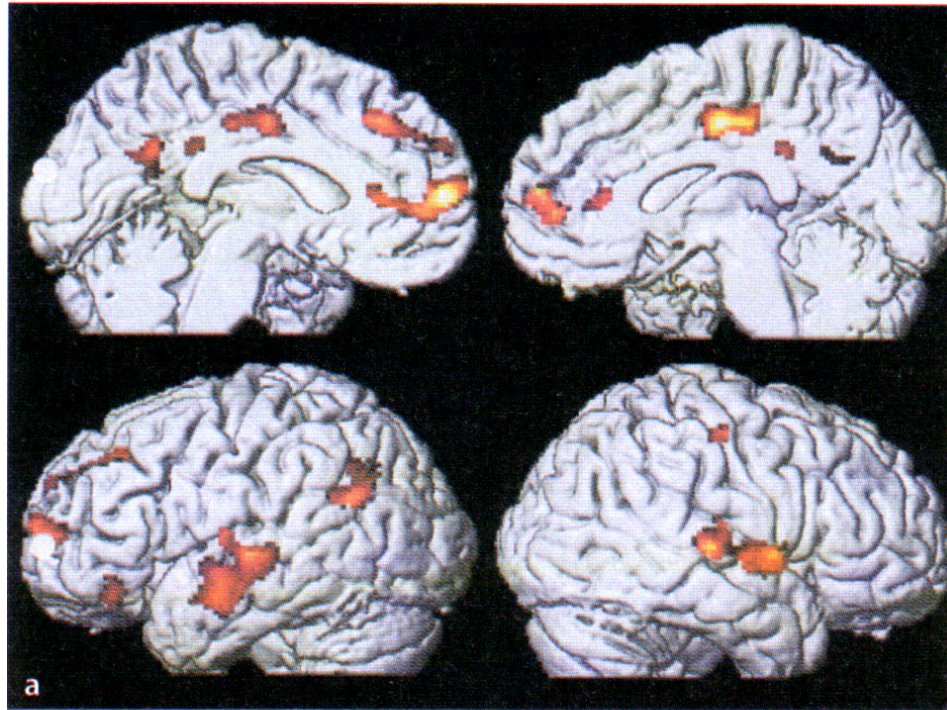
2. Arc-dependent consolidation



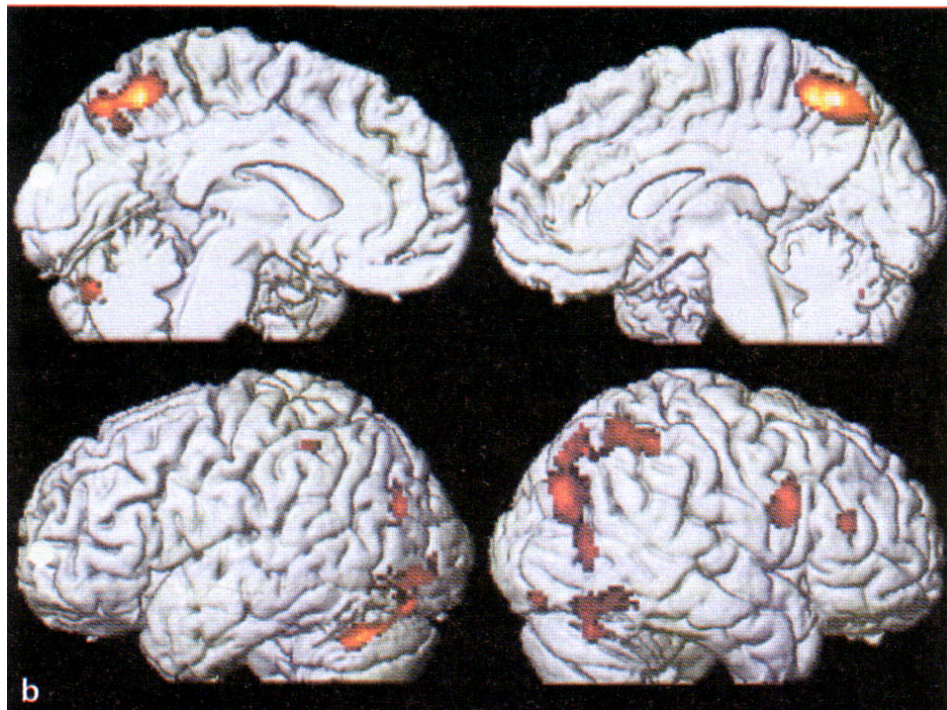
cortical surface



Diversity of structural rearrangements in the adult brain. A schematic of the types of structural rearrangements and associated synaptic changes (glutamatergic in green; GABAergic in red) observed by chronic *in vivo* two-photon imaging for cell types within L1 and L2/3 of the adult cortex during normal experience. This includes: **(a)** L5 pyramidal apical dendritic spines (~5–10% per week) [10,11**,12–16,17**,18*]; **(b)** L2/3 pyramidal dendritic spines (~5–10% per week) [11**,13,14]; **(c)** superficial L2/3 interneuron dendritic arbors (~3% per week, ~10 μm per arbor) [26,29**,30]; **(d)** L6 pyramidal axonal arbors (~20% per week, ~3 μm per arbor) and terminaux boutons (~20% per week) [36]; **(e)** L2/3 pyramidal axonal arbors (tens of microns over weeks, *retinal lesion) and *en passant* boutons (~7–12% per week) [36–38]; and **(f)** thalamocortical axonal arbors (~8% per week, ~2 μm per arbor), *en passant* (~4% per week) and *terminaux* boutons (~7% per week) [36].



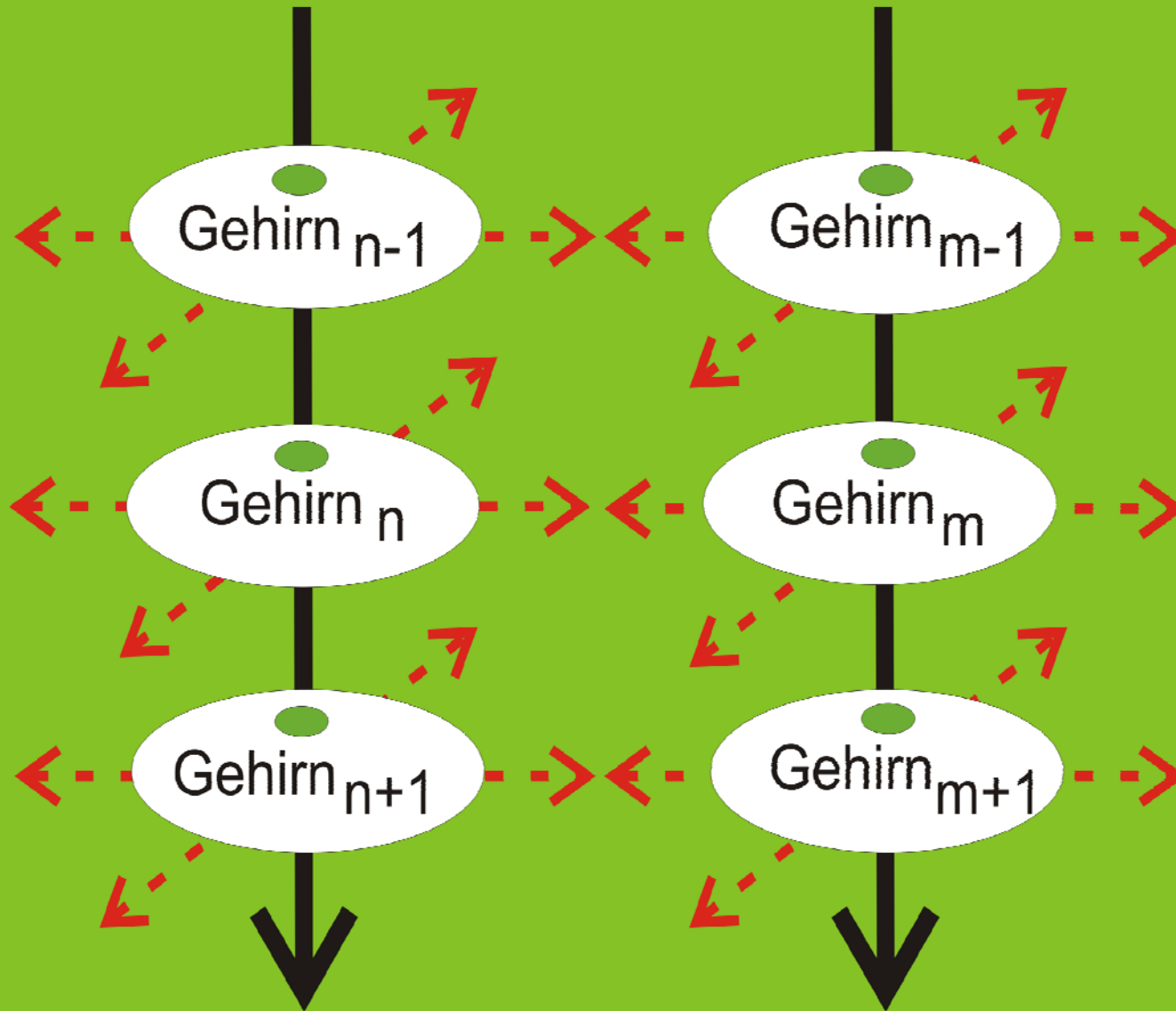
Ich-
Perspektive



Dritte-Person
Perspektive

Förstl H (2005)
Frontalhirn

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EVOLUTION