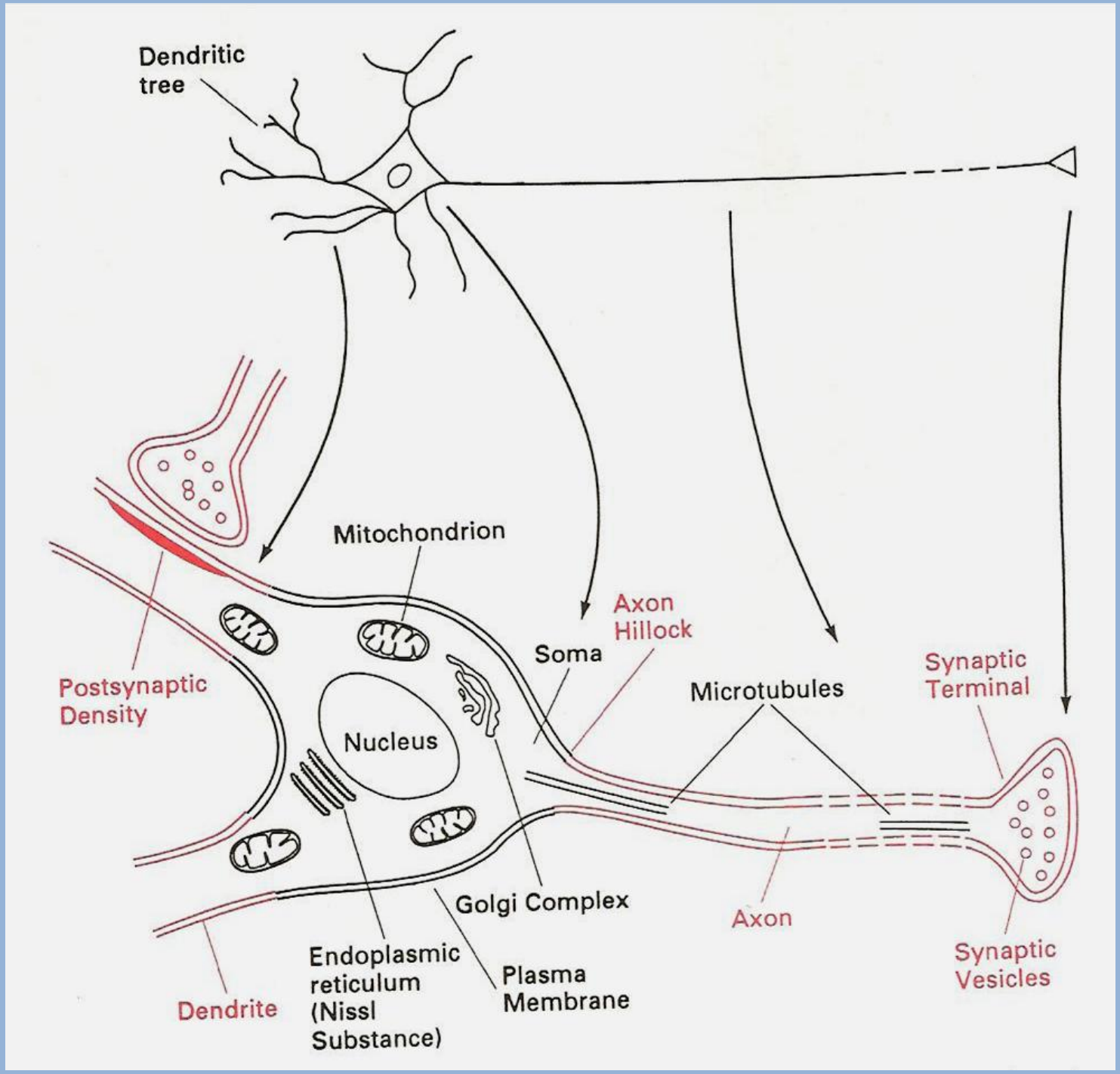
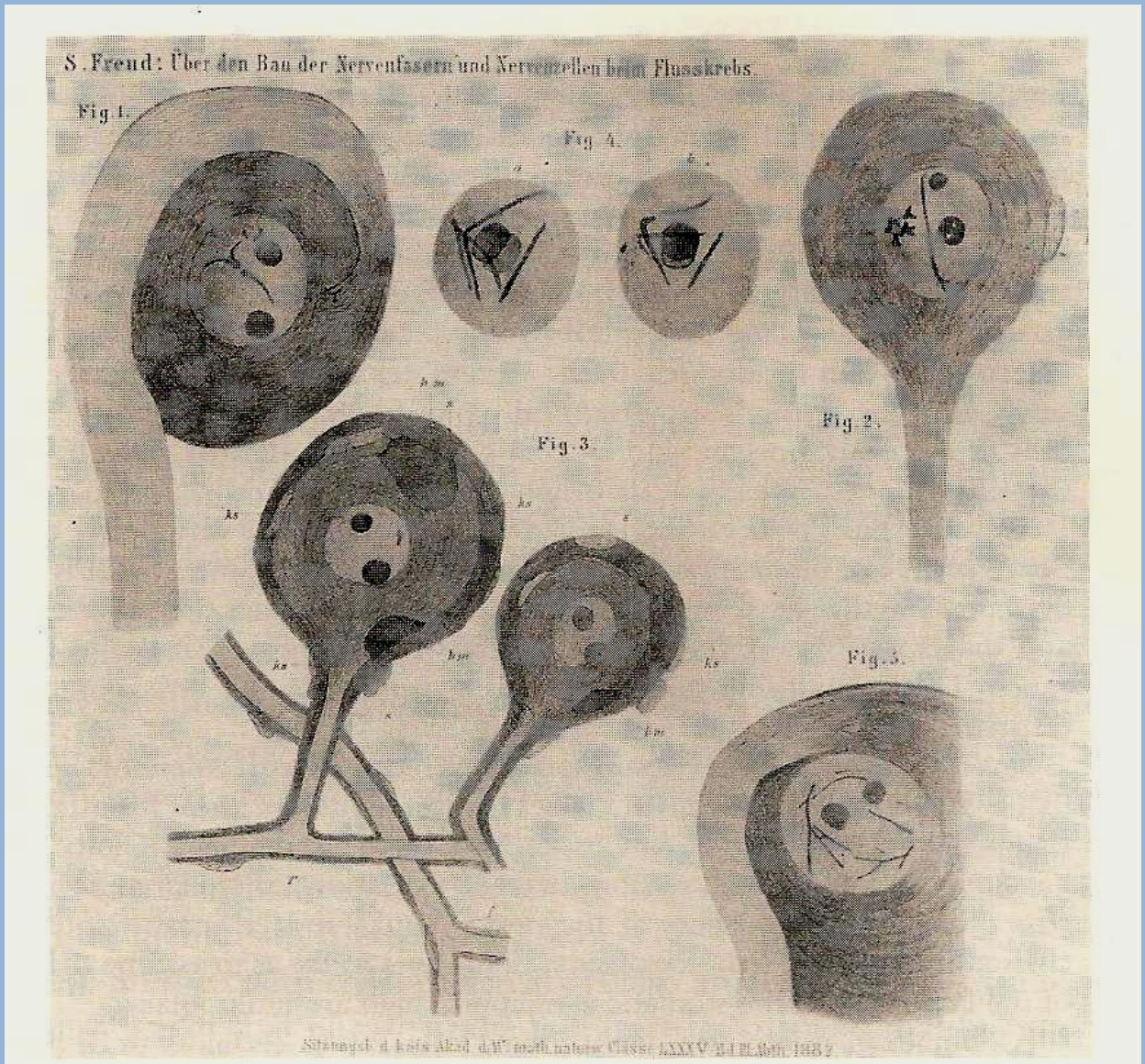
Classical and Chemical Neuroanatomy

Maria Panayotacopoulou, Professor of Neurobiology, National and Kapodistrian University of Athens and Mental Health Research Institute


Dendritic tree
Mitochondrion
Axon Hillock
Soma
Postsynaptic Density
Nucleus
Microtubules
Synaptic Terminal
Golgi Complex
Axon
Endoplasmic reticulum (Nissl Substance)
Plasma Membrane
Dendrite
Synaptic Vesicles



. 9. Illustrations of nerve cells by Sigmund Freud.

Project on Scientific Psychology (1895)

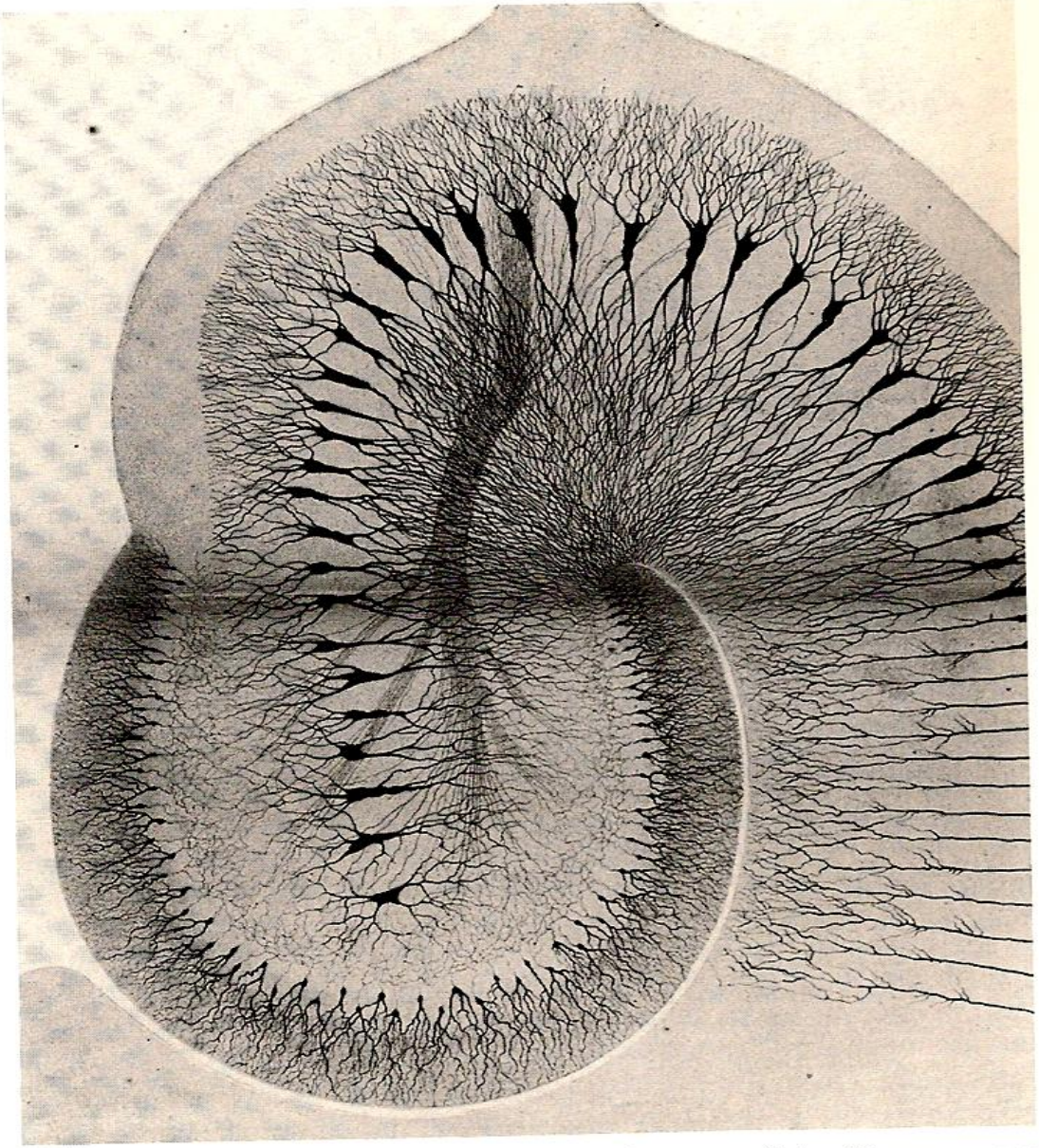
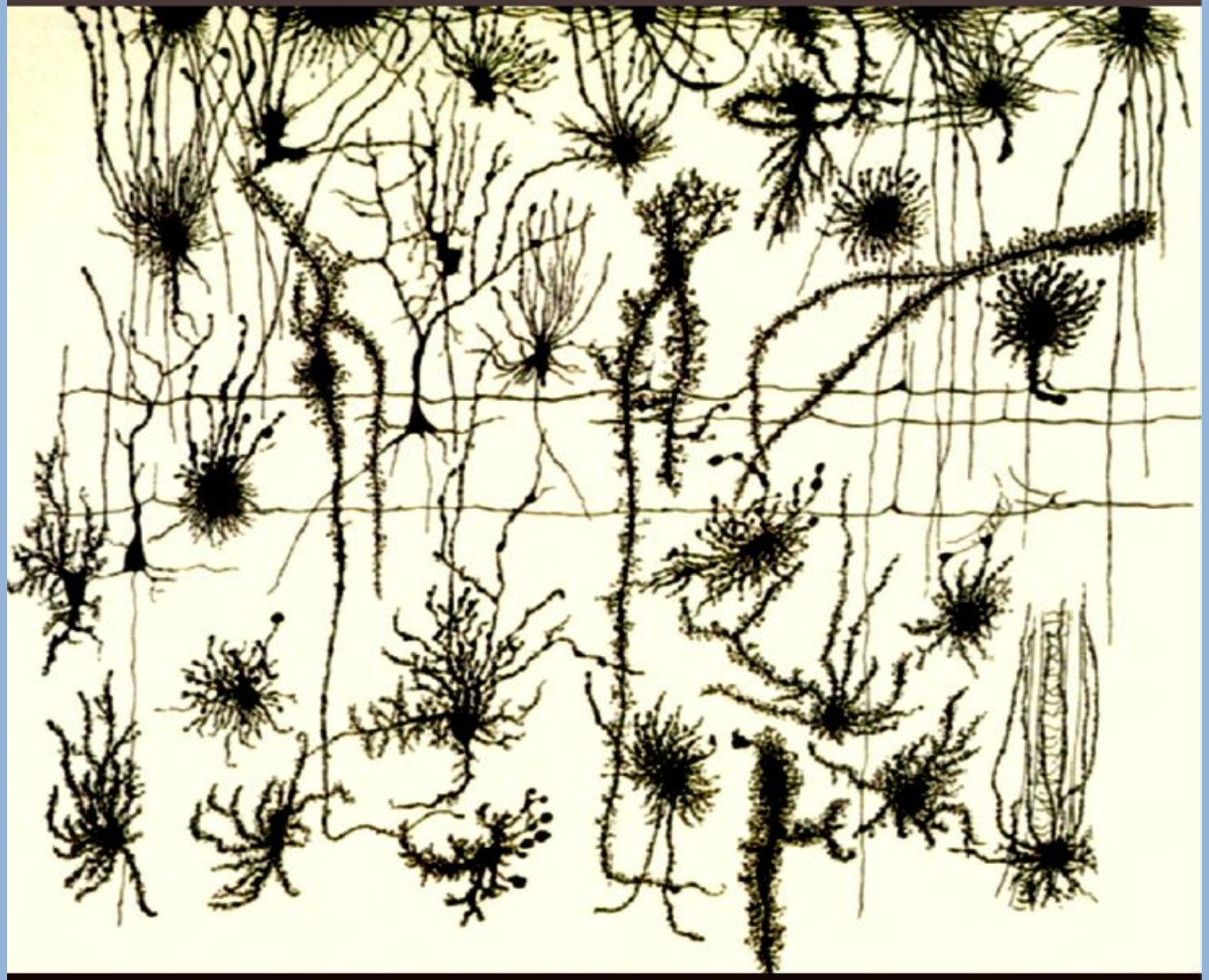


Fig. 13. A diagram by Golgi of the nervous elements of the hippocampus and fascia dentata.

Fig. 18. Portrait of Cajal in his laboratory, around 1890. Courtesy of P. Rakic, originally from P. Yakovlev.

Figure 1.5 Glial cells in the human cerebral cortex



A drawing of different types of glial cells of the cerebral cortex stained with the Golgi method. The original drawing was by Retzius in 1894. (Illustration courtesy of De Felipe, 2010, p 89)

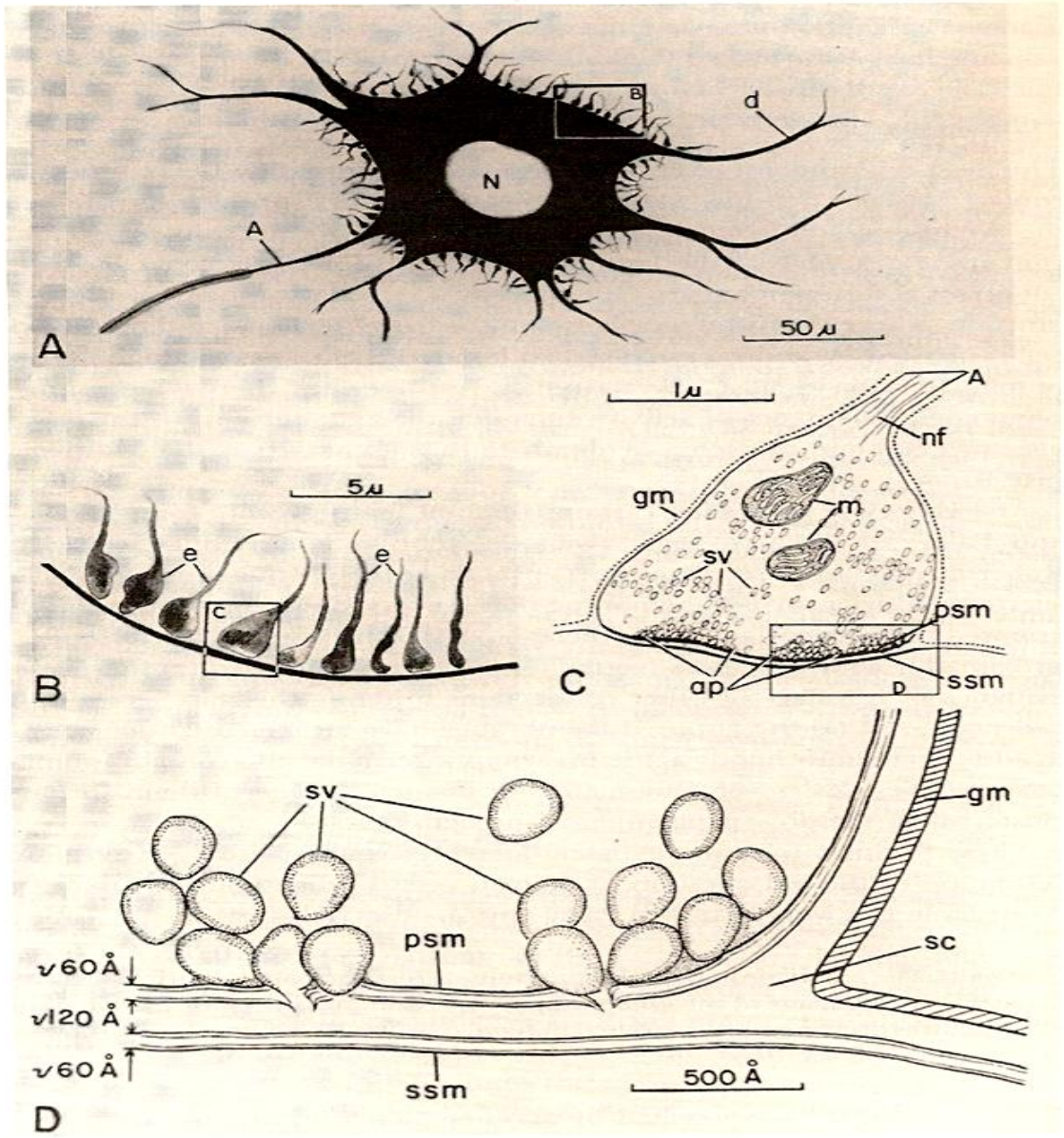
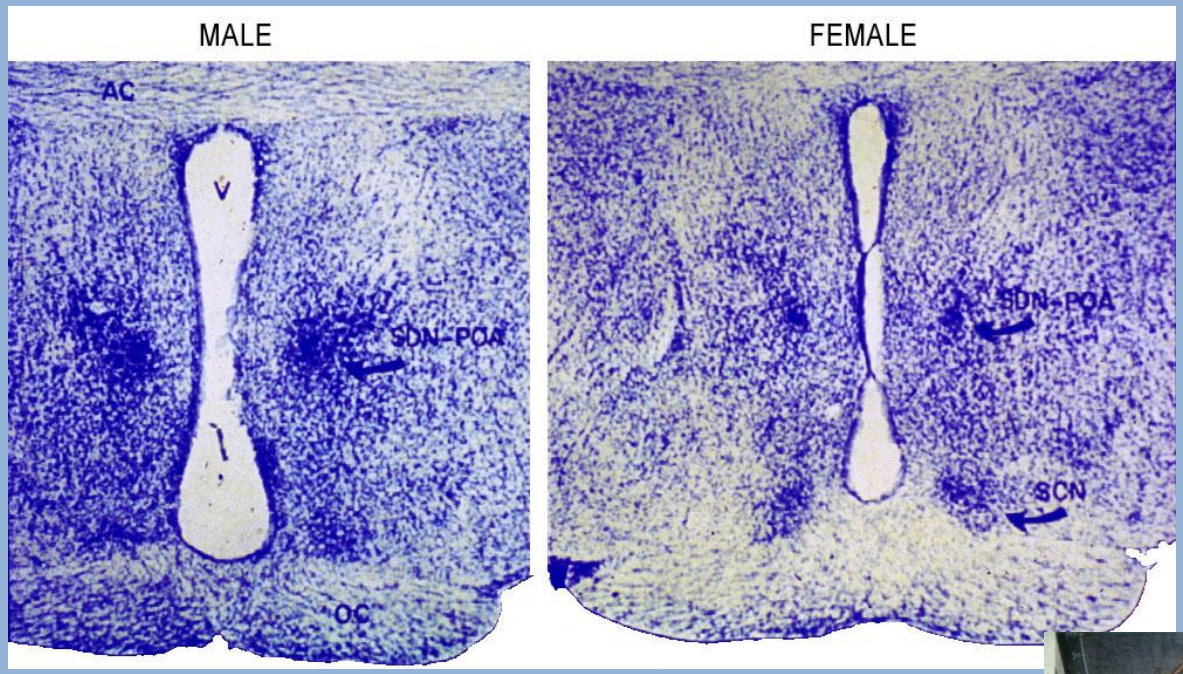


Fig. 39. "Diagram showing bouton-like synaptic junctions at different magnifications with the optical and electron microscope. (A) Illustrates a motoneuron as seen at medium power of the optical microscope. The nucleus (*N*), the axon (*A*), and the dendrites (*d*) are indicated. Numerous bouton-like endings make synaptic contact

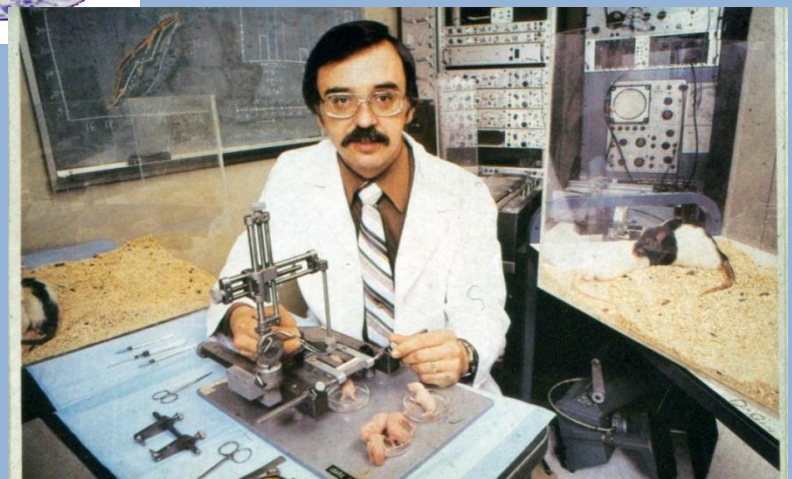
Figure 1.3 Electron microscope picture of a synapses in the cerebral cortex

This is an electron micrograph of a very thin section of cerebral cortex. A large dendrite (D) runs diagonally across the section. Most of the unstained (white) structures are dendritic spines (Sp), one of which is attached to the large dendrite. Most of the darker staining structures are terminal boutons (B) full of round synaptic vesicles. Dark synaptic thickenings (Sy) are seen at the junction of some dendritic spines and boutons.

Sexual dimorphic nucleus (SDN) of the preoptic area is 3-8 times larger in male rats than in female rats



Gorski RA et al (1978)
Brain Res, 148: 333-346



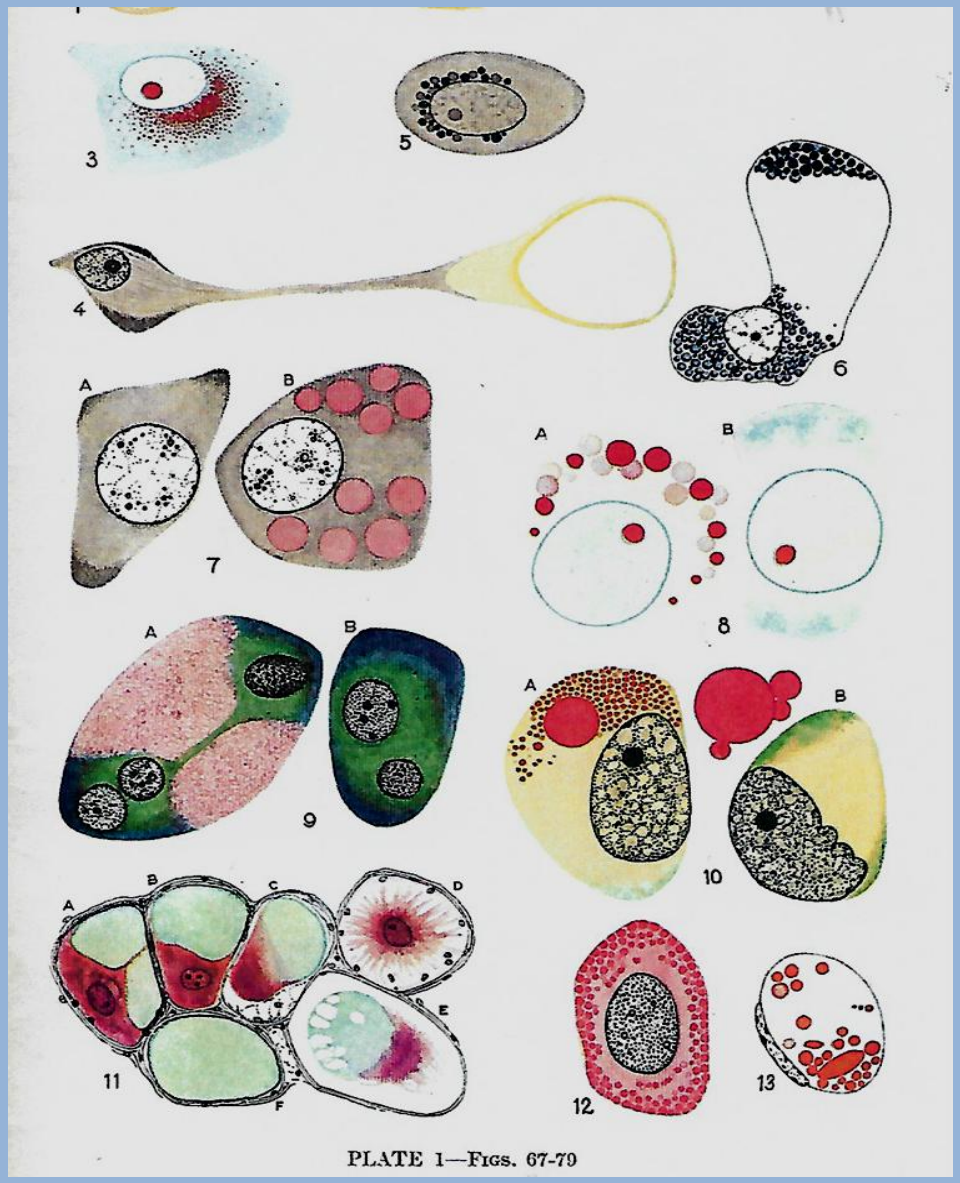
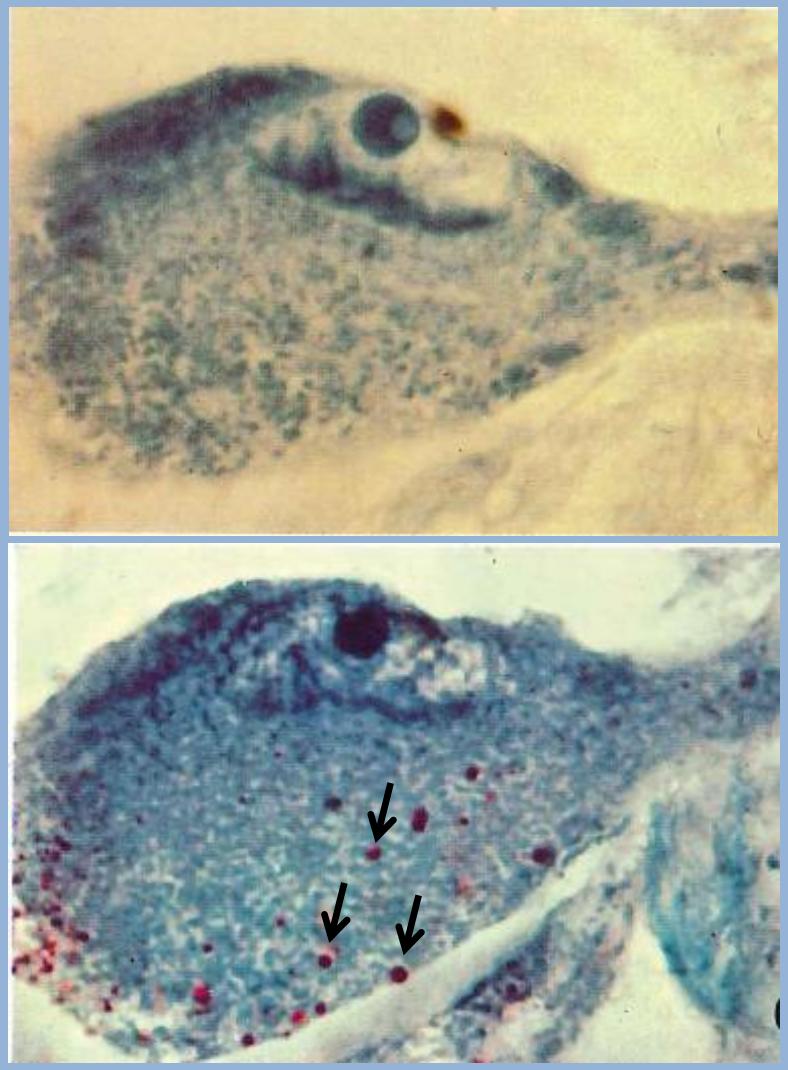


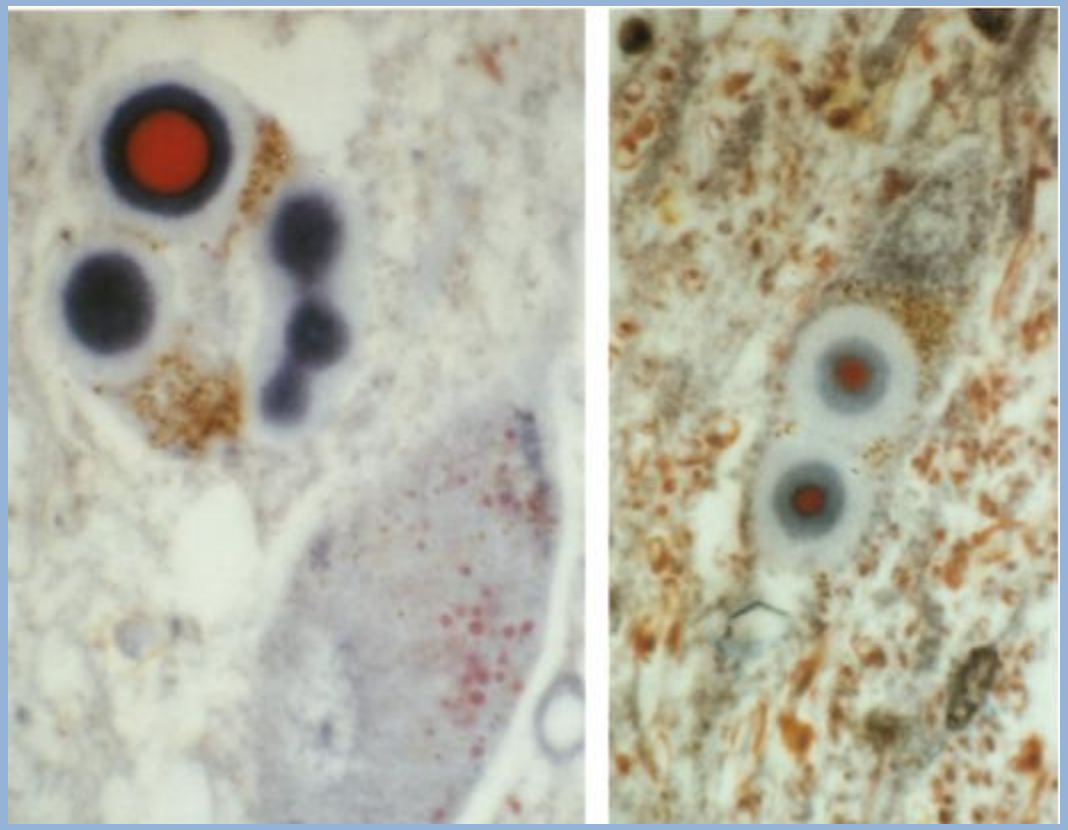
PLATE 1—FIGS. 67-79

Secretory cells within the Hypothalamus, by Scharrer E. and Scharrer B, The Association for Research in Nervous and Mental Disease, 1940, 170-194

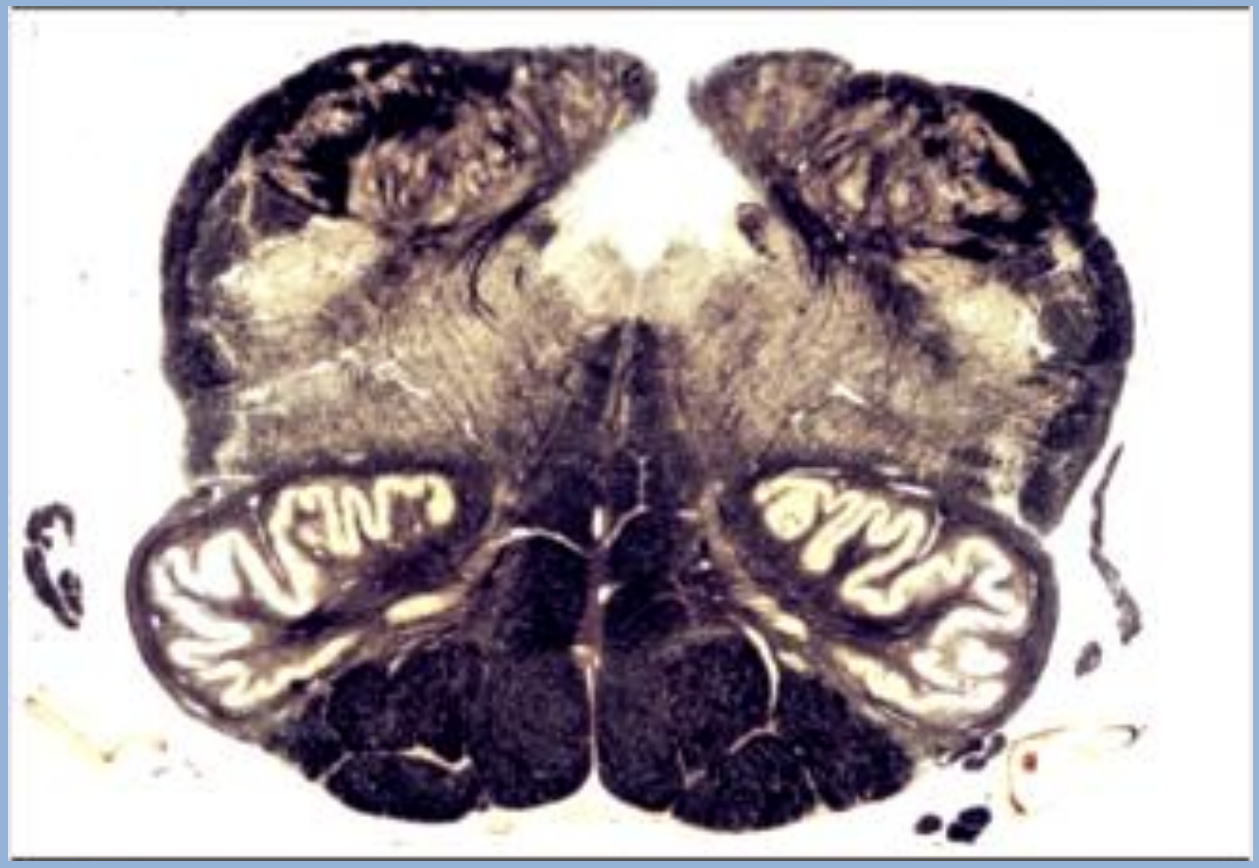
Fig. 84. Nerve cell from the nucleus paraventricularis of the capuchin monkey (*Cebus capucinus*). The cell body is completely filled with granules (see also Plate 1, Fig. 68). Fix. Bouin's fluid, celloidin, Van Gieson stain, 2600 ×.



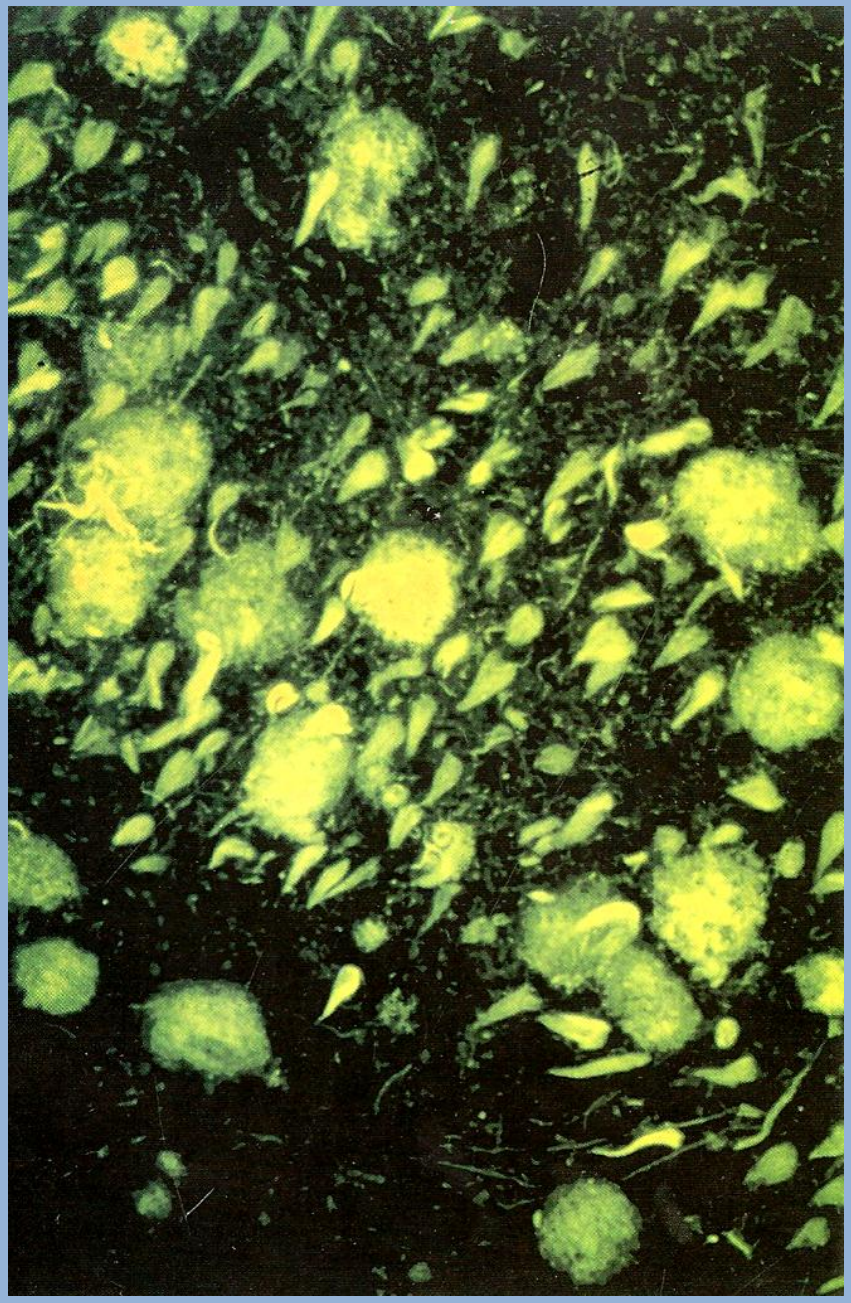
One raphe neuron in two parallel sections stained for Nissl (up) and Mallory's trichrome (bottom). Note acidophilic protein bodies (arrow, basic charge) stained in red by acid fuschin (Panayotacopoulou and Issidorides, *Arch Neurol*, 1982)



Neurons of locus coeruleus (left) and substantia nigra (right) of a Parkinsonian patient stained with Mallory trichrome. Note the center of Lewy Body stained in red by acid fuchsin due to its basic charge (Issidorides et al., 1991; *J Neuronal Trans* 3:49-61)



Section of human hindbrain stained with Weigert method for myelin. The myelin appears brown or black. At the bottom there is a dense brown staining in the corticospinal tracts (from :THE BRAIN, an introduction to functional neuroanatomy, Watson, Kirkaldie, Paxinos, Elsevier 2010).

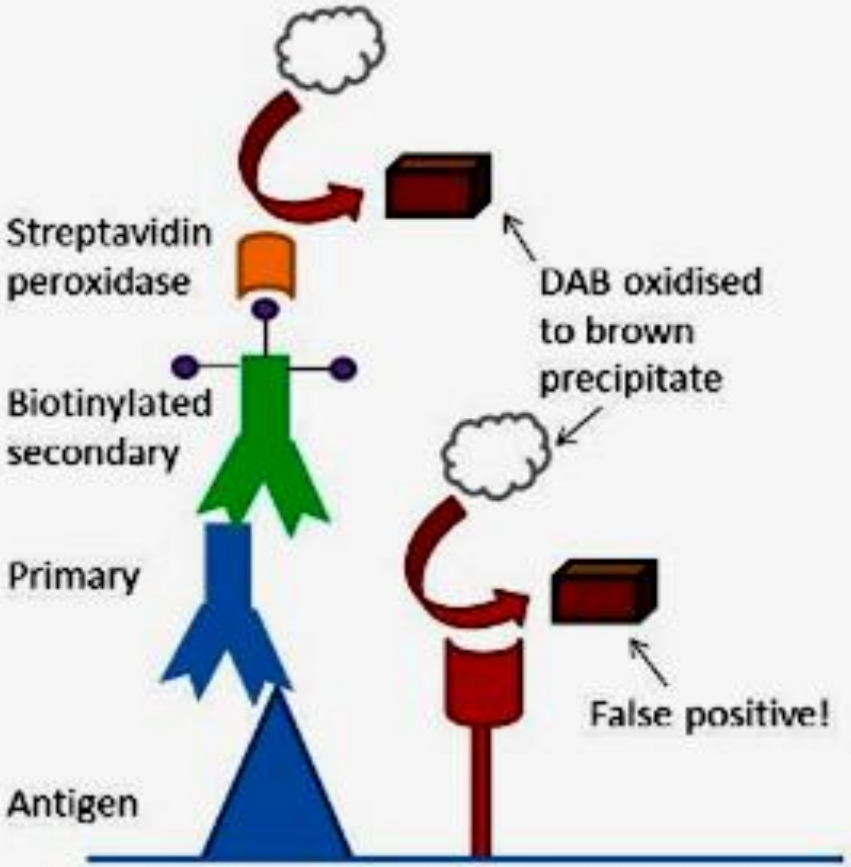


Chemical and Molecular Neuroanatomy combines informations from:

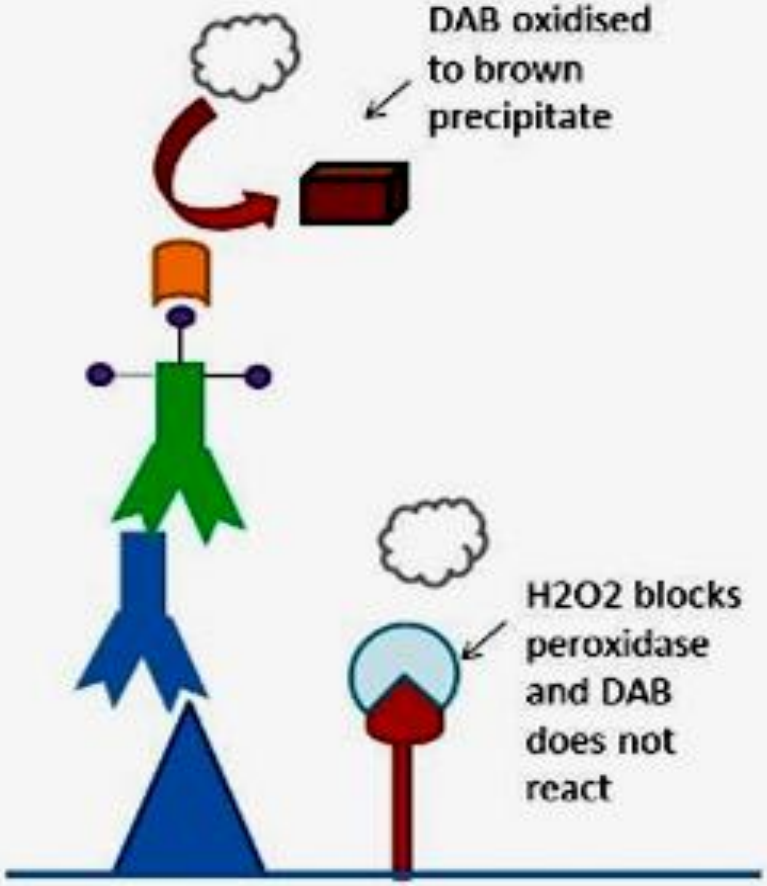
- Classical neuroanatomy
- Classical histochemistry
- Molecular Biology
- Neurochemistry
- Neurophysiology
- Neuropharmacology

Applications of Chemical Neuroanatomy

- In experimental **animal brain** to study: differences in brain regions in neurotransmitter or receptor expression after experimental manipulations (eg. under stress conditions, under specific medication, in animal models)
- In the **human brain** to study the etiopathology of neurological, psychiatric or endocrinological disorders.



In tissue where endogenous peroxidase activity hasn't been blocked, DAB will react with peroxidase naturally found in the tissue and give a false positive background result.



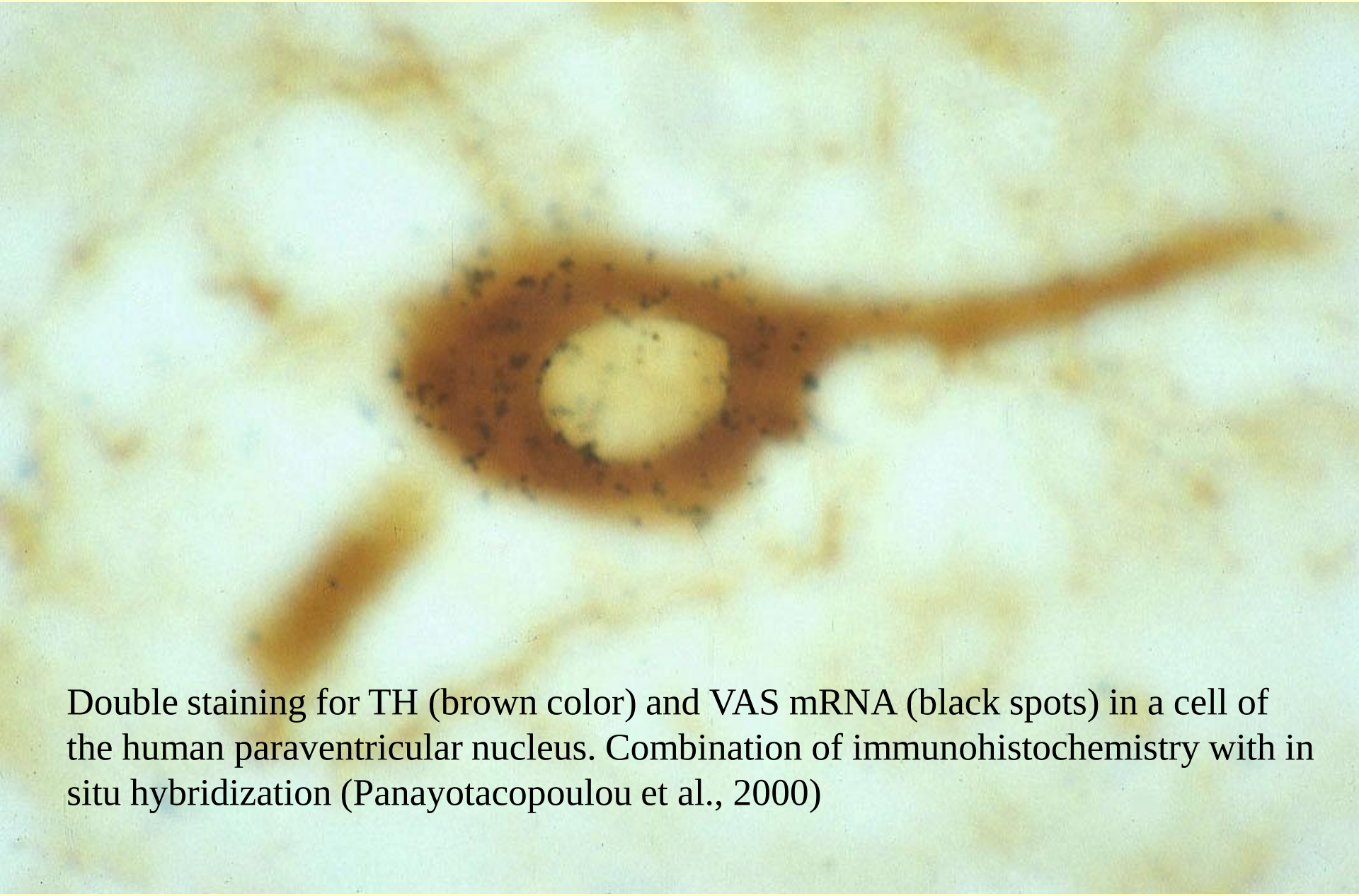
Blocking this peroxidase activity by incubation with hydrogen peroxide (H2O2) eliminates this problem.

Basic methodology:

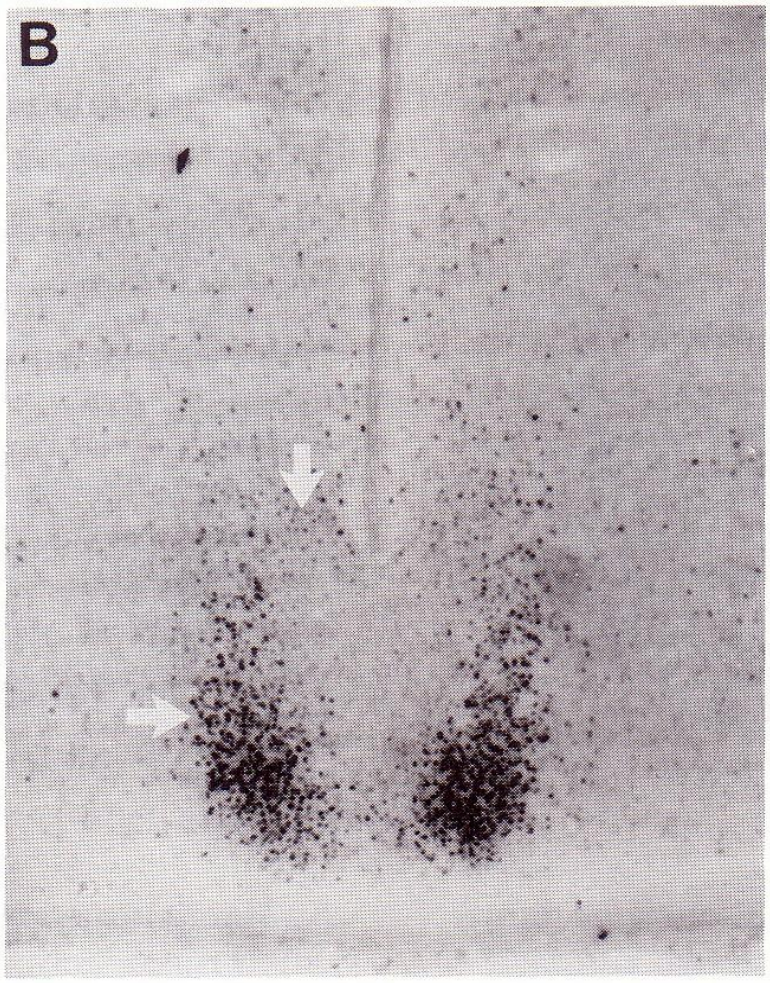
a) Immunohistochemistry (one or multiple antigens)
b) In situ hybridization (mRNA or DNA Probes)
c) Autoradiography
c) Combination of the above
d) Staining / laser microdissection / single neuron PCR

Microscopic observation by:

- Light microscopy
- Fluorescence microscopy/ Confocal microscopy
- Electron Microscopy



Double staining for TH (brown color) and VAS mRNA (black spots) in a cell of the human paraventricular nucleus. Combination of immunohistochemistry with in situ hybridization (Panayotacopoulou et al., 2000)


B


C

Table 1.1 A table of common neurotransmitters

Neurotransmitter	Descriptive name	Typical functions
glutamate (glu)	glutamatergic	CNS excitation
aspartate (asp)		brain, spinal cord excitation
γ-aminobutyric acid (GABA)	GABAergic	CNS inhibition
glycine (gly)	glycinergic	rapid inhibition in spinal cord
acetylcholine (ACh)	cholinergic	muscle/autonomic activation; attention
dopamine (DA)	dopaminergic	reward; movement
noradrenaline (NA) [a.k.a. norepinephrine (NE)]	noradrenergic	arousal; smooth muscle control
serotonin (5-HT)	serotonergic	relaxation; mood; sensory processing
substance P (SP)	peptidergic	pain signaling, other functions
neuropeptide Y (NPY)		appetite control
opioids (Enk)		pain modulation; satiety
adenosine triphosphate (ATP)	purinergic	many functions

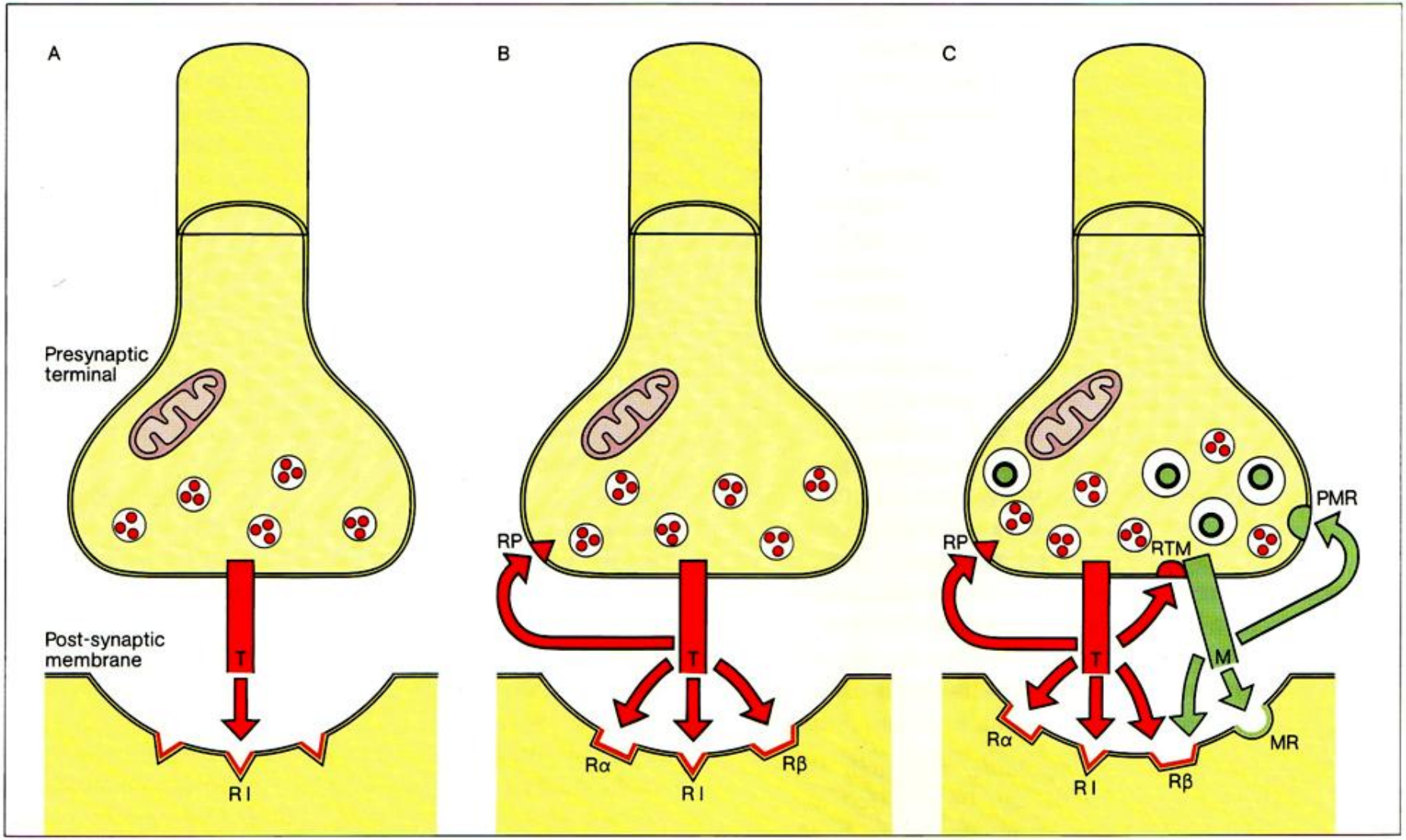
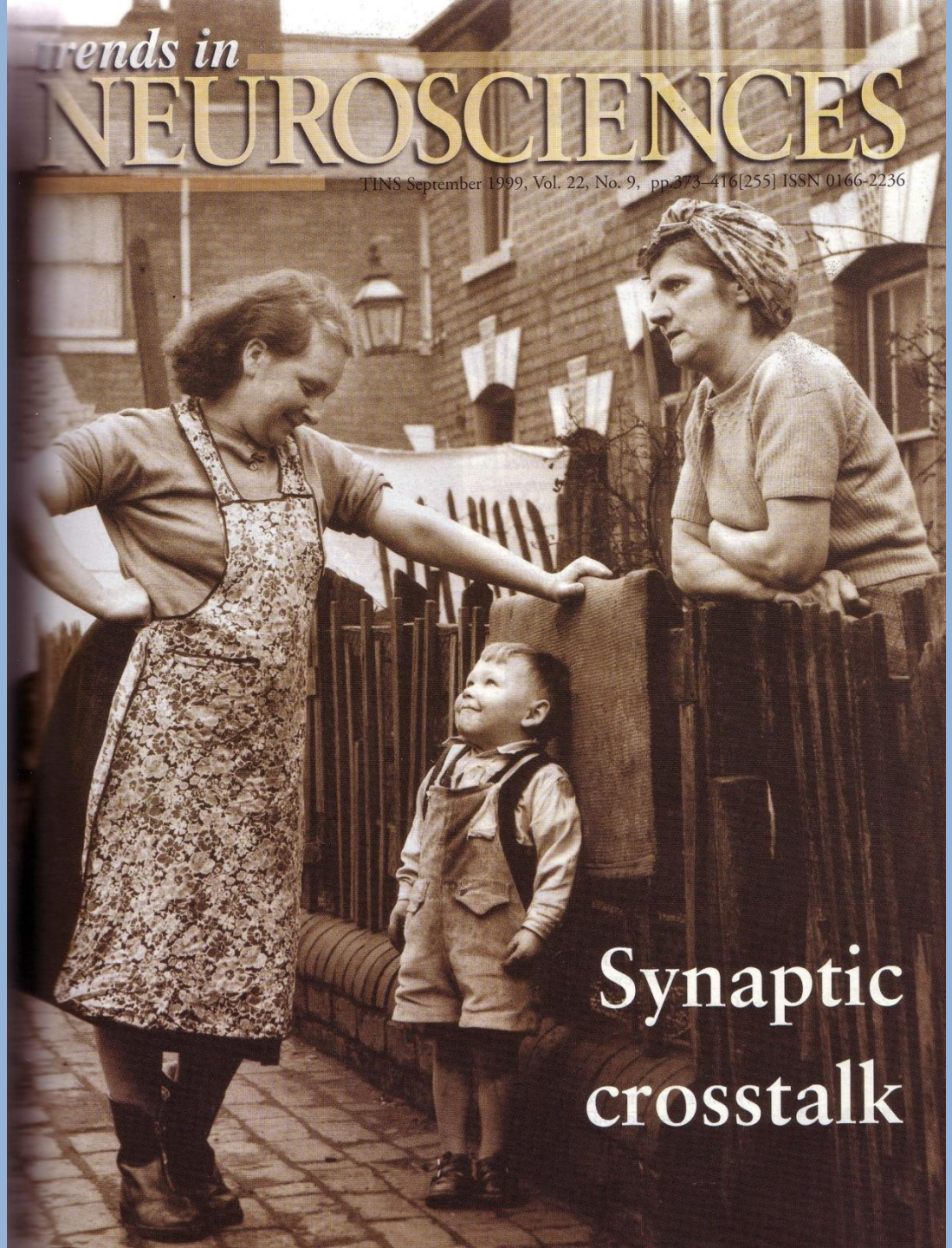


Fig. 4 A–C. *Some mechanisms of release and interaction of multiple transmitters (small vesicles containing classical transmitter **T**; larger, dense-core vesicles containing transmitter **T** and a neuropeptide **M**). In **A**, **T** acts on a single postsynaptic receptor **RI**. In **B**, **T** acts on multiple types of postsynaptic receptor **RI**, **Rα**, **Rβ** and on a presynaptic autoreceptor **RP** to control its own release. In **C**, **T** and **M** are both released. **T** can inhibit the release of **M** at a presynaptic receptor **RTM**; **M** acts on its own postsynaptic receptor **MR** and at a presynaptic receptor **PMR** to modulate synaptic transmission. Modified from Lundberg and Hökfelt [19]*

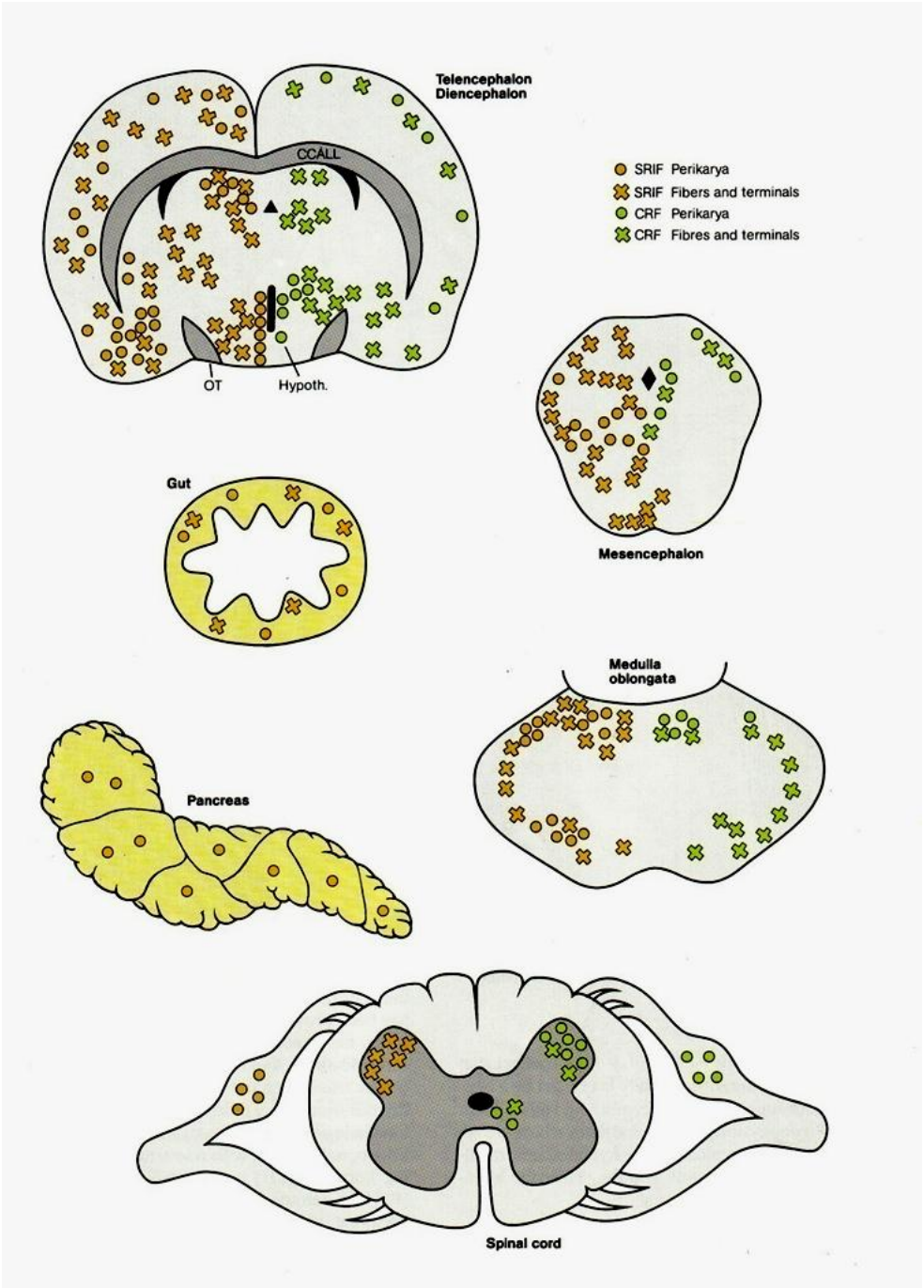
Trends in
NEUROSCIENCES
TINS September 1999, Vol. 22, No. 9, pp.373–416[255] ISSN 0166-2236



Synaptic crosstalk

Πίνακας 16-3 Ορισμένες οικογένειες νευροδραστικών πεπτιδίων

Οπιοειδή	Οπιοκορτίνες, εγκεφαλίνες, δυνορφίνη, FMRFαμίδιο
Νευροϋποφυσιαία	Αγγειοπιεσίνη, ωκυτοκίνη, νευροφυσίνες
Ταχυκινίνες	Ουσία P, φυσαλαιμίνη, κασσινίνη, ουπερολεΐνη, ελεδουασίνη, βομβεσίνη, ουσία K (νευροκινίνη A)
Σεκρετίνες	Σεκρετίνη, γλυκαγόνη, αγγειοδραστικό εντερικό πολυπεπτίδιο, γαστρικό ανασταλτικό πεπτίδιο, απελευθερωτικός παράγοντας της αυξητικής ορμόνης, πεπτίδιο ισολευκιναμίδιο της ιστιδίνης
Ινσουλίνες	Ινσουλίνη, αυξητικοί παράγοντες I και II που μοιάζουν με την ινσουλίνη
Σωματοστατίνες	Σωματοστατίνη, παγκρεατικό πολυπεπτίδιο
Γαστρίνες	Γαστρίνη, χοληκυστοκινίνη


Telencephalon
Diencephalon
CCALL
OT
Hypoth.
SRIF Perikarya
SRIF Fibers and terminals
CRF Perikarya
CRF Fibres and terminals
Mesencephalon
Gut
Medulla oblongata
Pancreas
Spinal cord

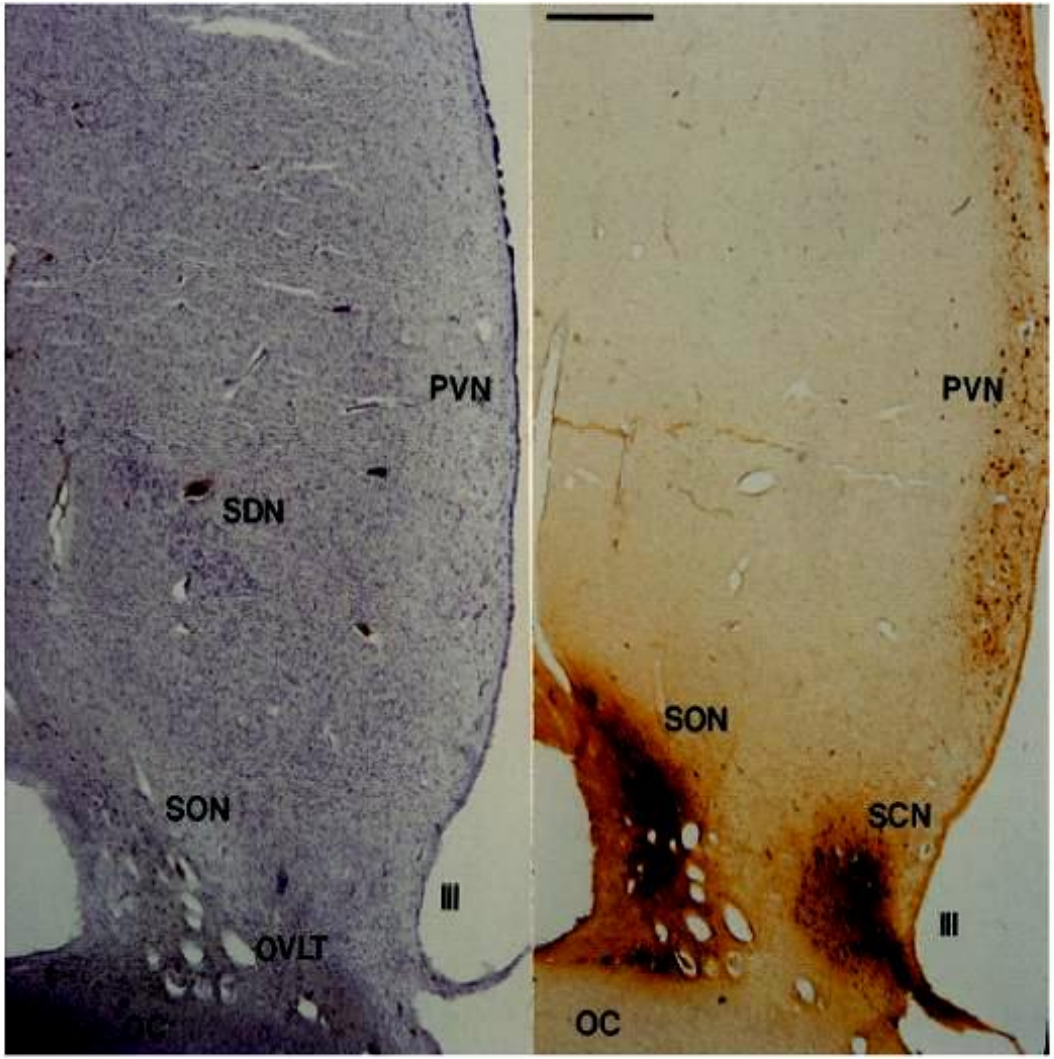


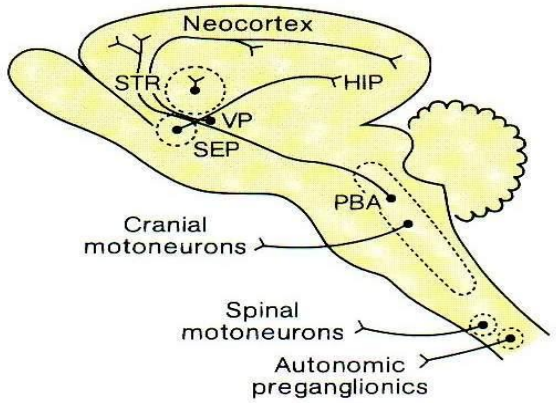
Fig. 1.7. Thionine- (left) and anti-vasopressin (right)-stained section through the chiasmatic or preoptic region of the hypothalamus. OC = optic chiasm, OVLT = organum vasculosum lamina terminalis, PVN = paraventricular nucleus, SCN = suprachiasmatic nucleus, SDN = sexually dimorphic nucleus of the preoptic area (intermediate nucleus, INAH-1), SON = supraoptic nucleus, III = third ventricle. Bar represents 1 mm.

TABLE 14–1. Small-Molecule Transmitter Substances and Their Key Biosynthetic Enzymes

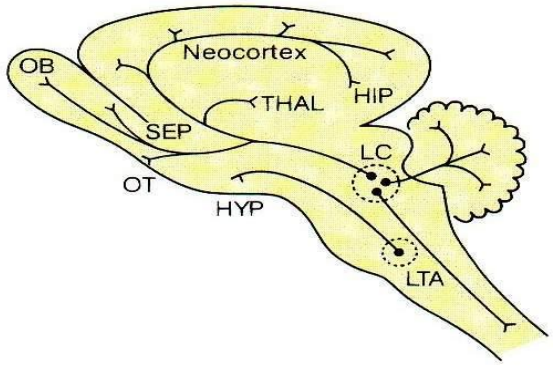
Transmitter	Enzymes
Acetylcholine	Choline acetyltransferase (specific)
Biogenic amines	
Dopamine	Tyrosine hydroxylase (specific)
Norepinephrine	Tyrosine hydroxylase and dopamine β-hydroxylase (specific)
Epinephrine	Tyrosine hydroxylase and dopamine β-hydroxylase (specific)
Serotonin	Tryptophan hydroxylase (specific)
Histamine	Histidine decarboxylase (specificity uncertain)
Amino acids	
γ-Aminobutyric acid	Glutamic acid decarboxylase (probably specific)
Glycine	General metabolism (specific pathway undetermined)
Glutamate	General metabolism (specific pathway undetermined)

From: Principles of Neural Sciences, by Kandel et al., Elsevier,1991

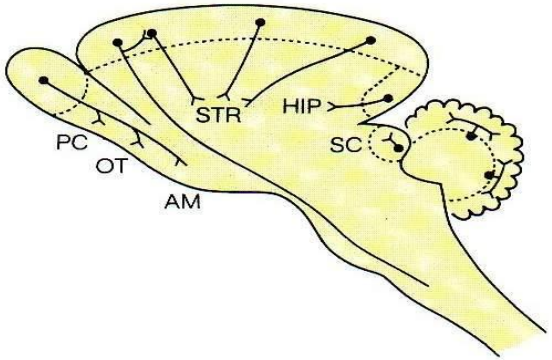
Acetylcholine



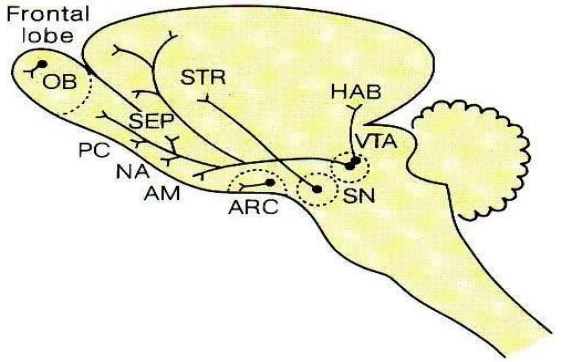
Noradrenaline



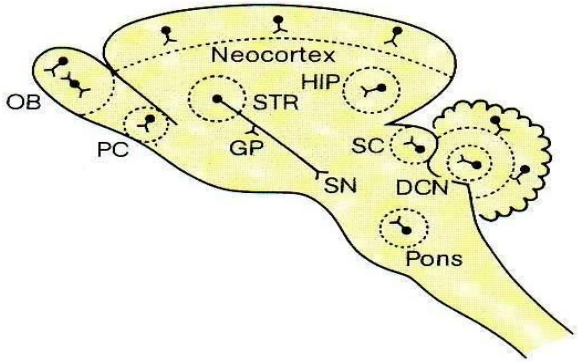
Glutamate/aspartate



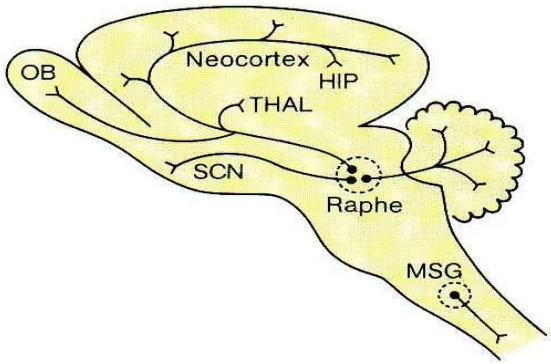
Dopamine



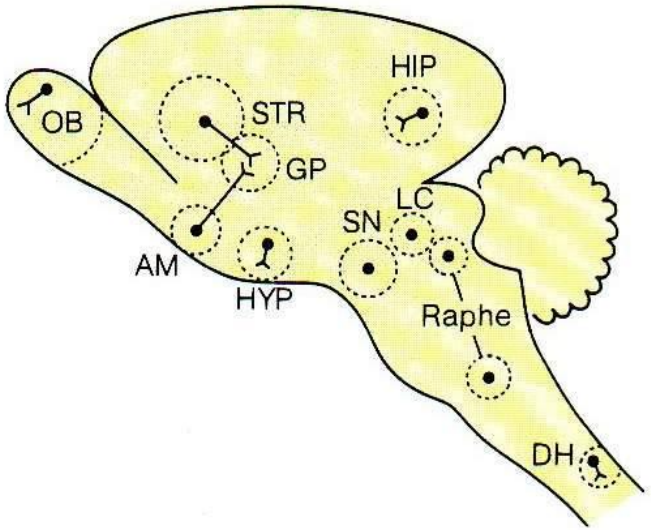
GABA



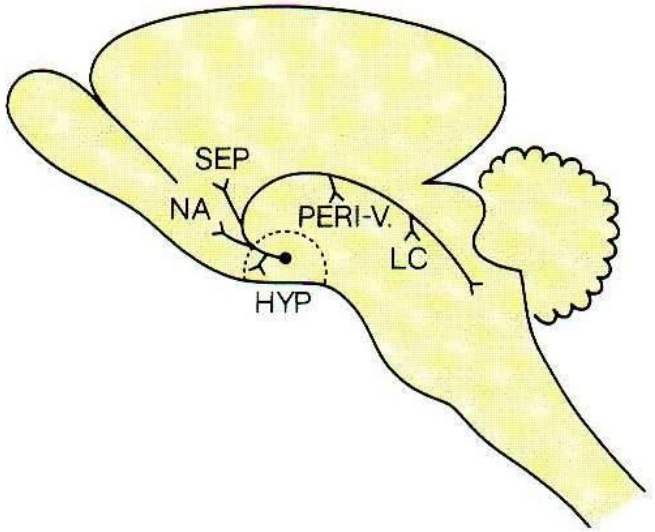
5-Hydroxytryptamine



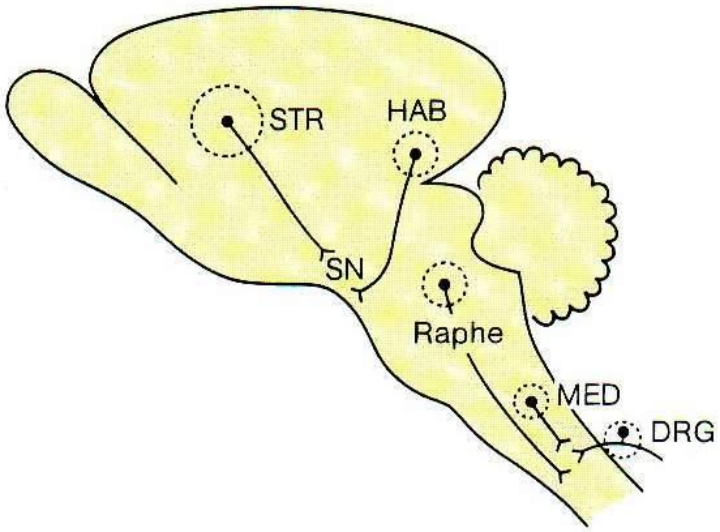
Enkephalin



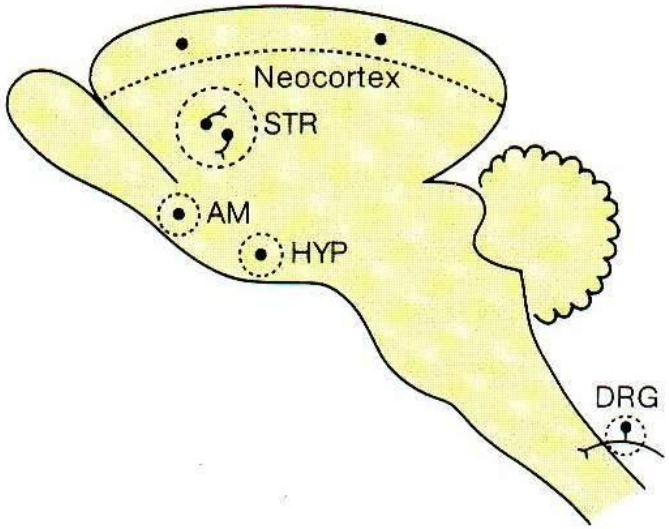
Endorphin

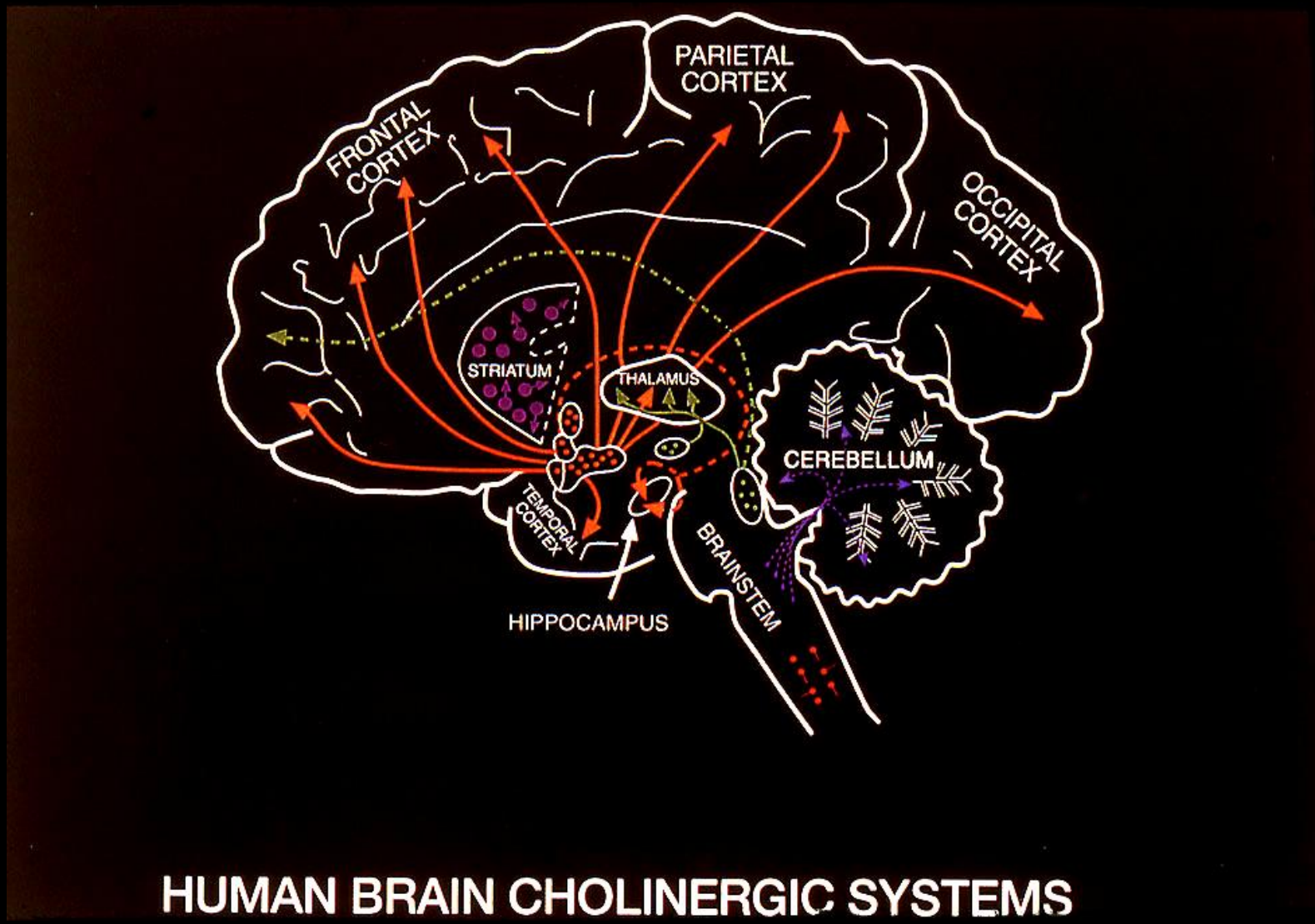


Substance P



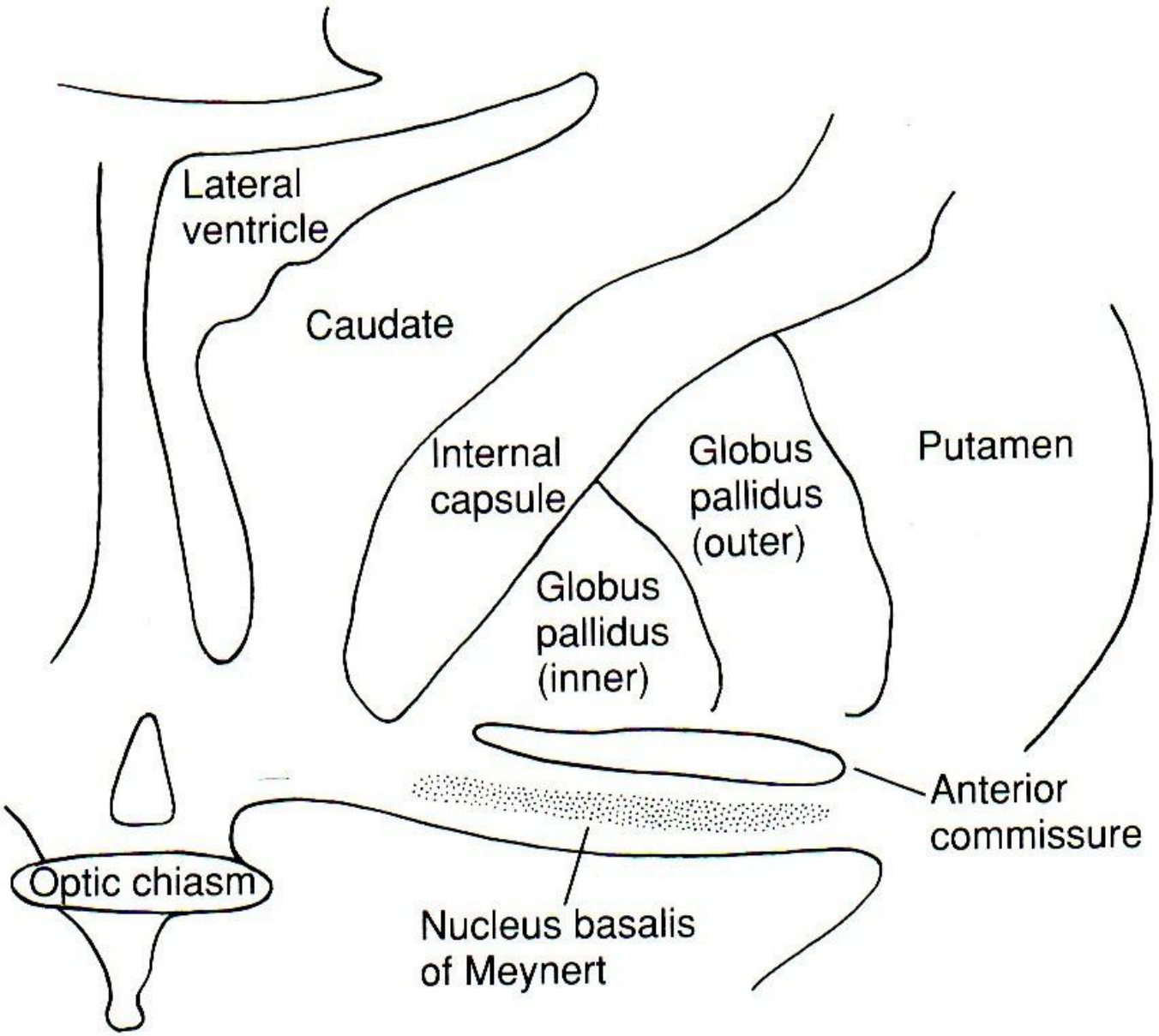
Somatostatin





HUMAN BRAIN CHOLINERGIC SYSTEMS

A


Lateral ventricle
Caudate
Internal capsule
Globus pallidus (outer)
Putamen
Globus pallidus (inner)
Anterior commissure
Optic chiasm
Nucleus basalis of Meynert

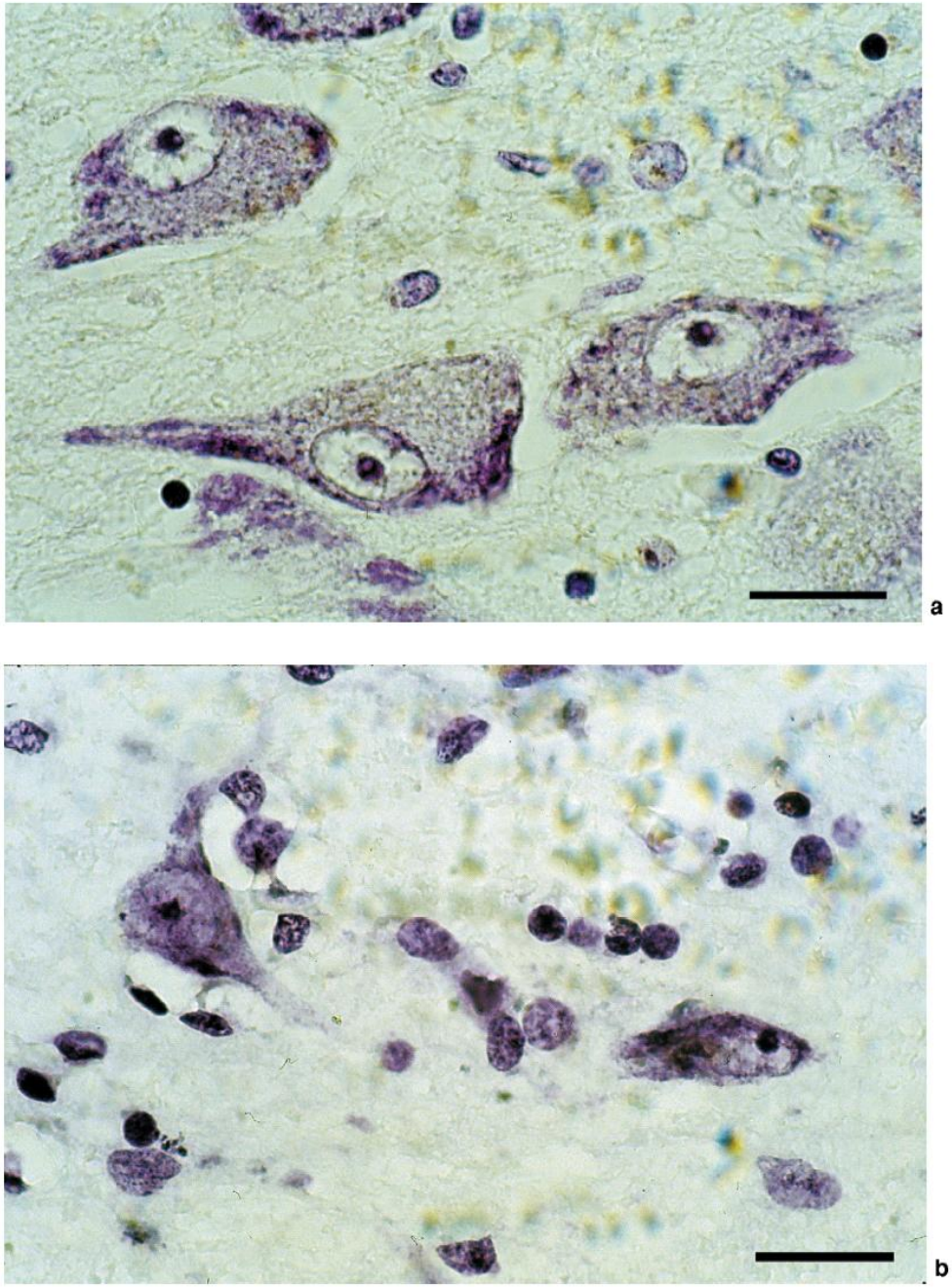
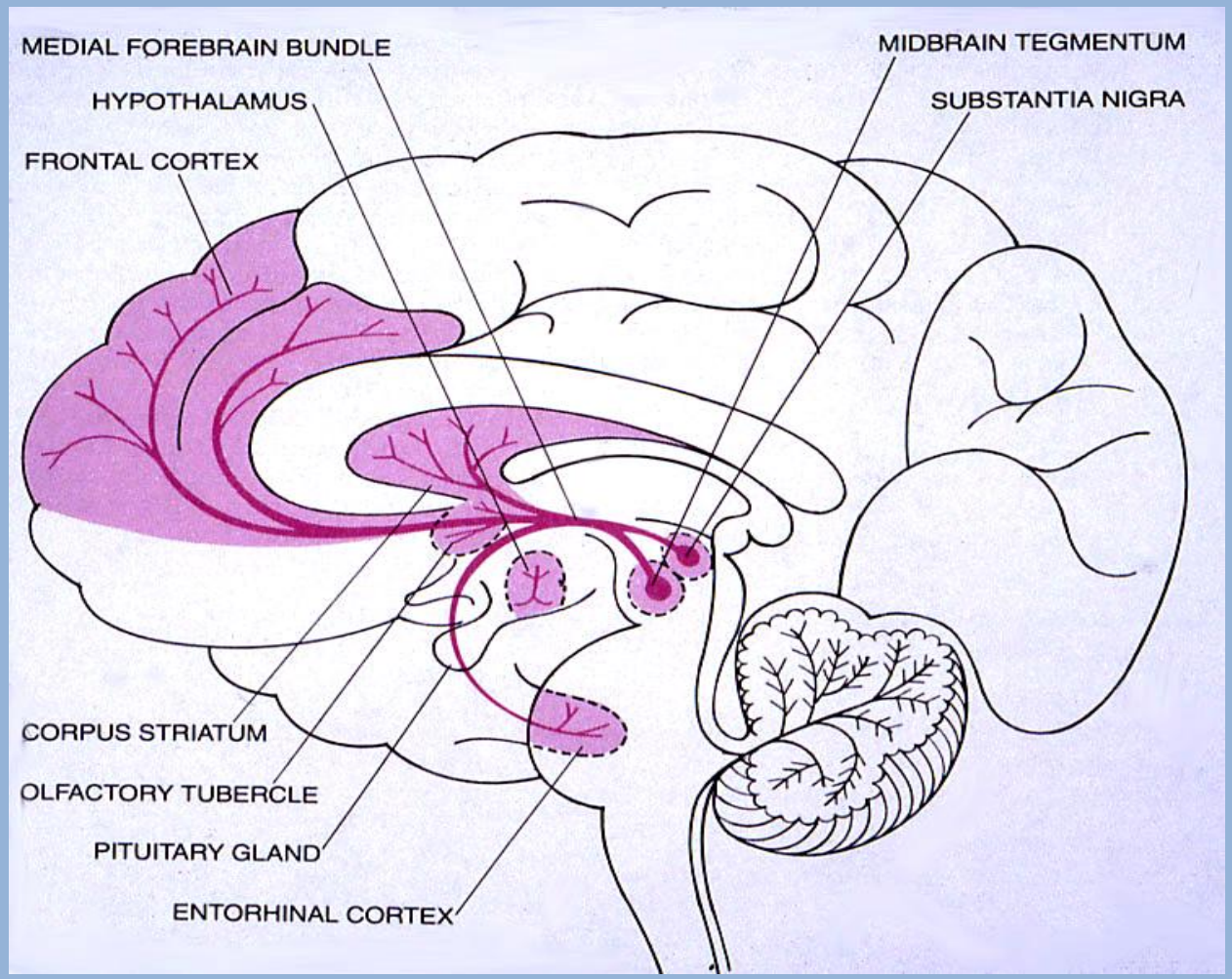


Fig. 2.2. Conventional (thianine) staining of the nucleus basalis of Meynert (NBM) of a control case (a) and a patient with Alzheimer's disease (b). Note the large neurons in the control (a) and the presence of smaller, atrophied neurons in the Alzheimer patient. Bar indicates 20 μm.



Dopaminergic neurons and their projections in mesolimbic and cortical areas

a) are involved in schizophrenia and ADHD

b) are targets of neuroleptic treatment

c) dopaminergic innervation in the cortex of primates appears to

reach maturation in adulthood

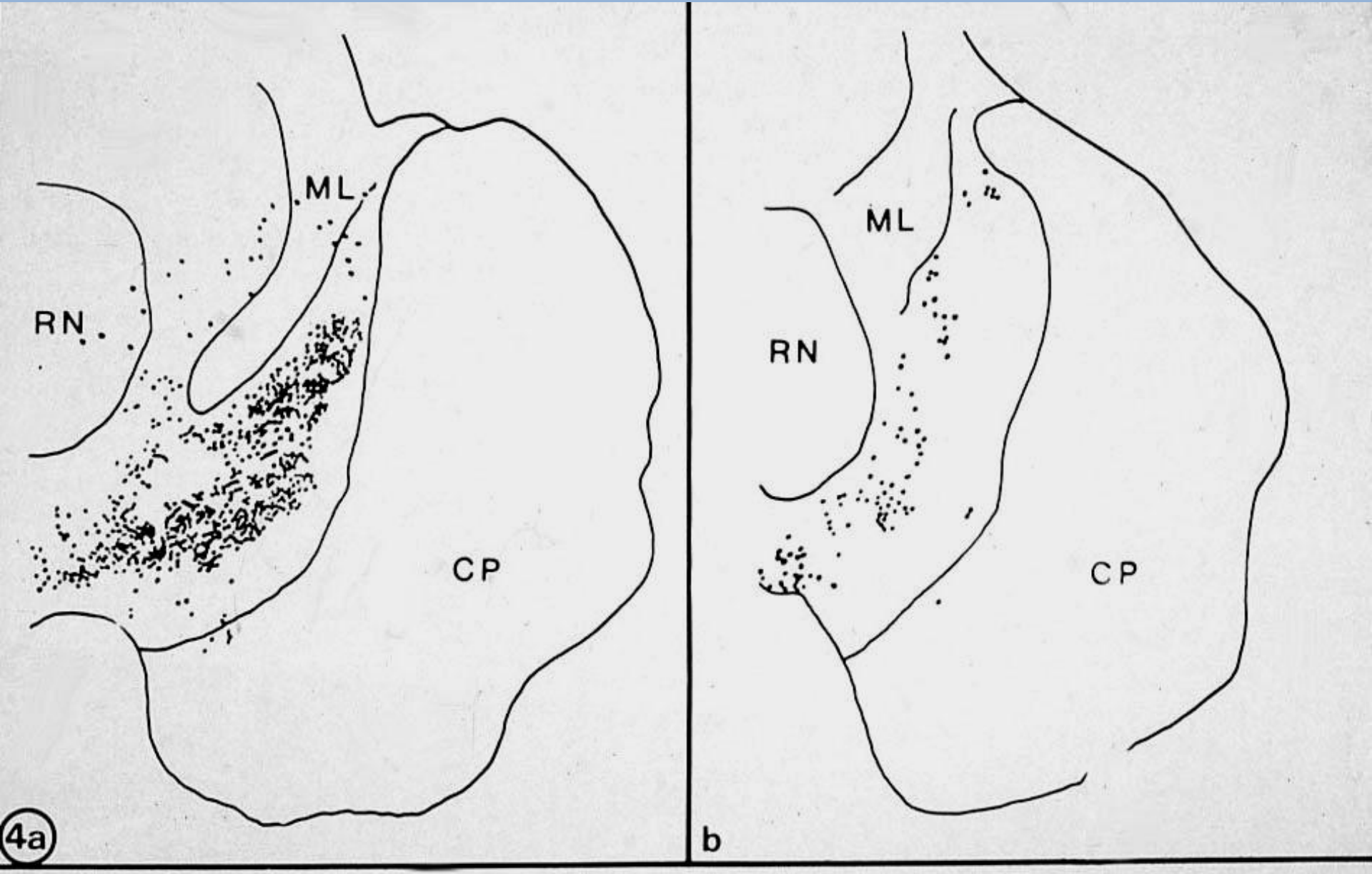


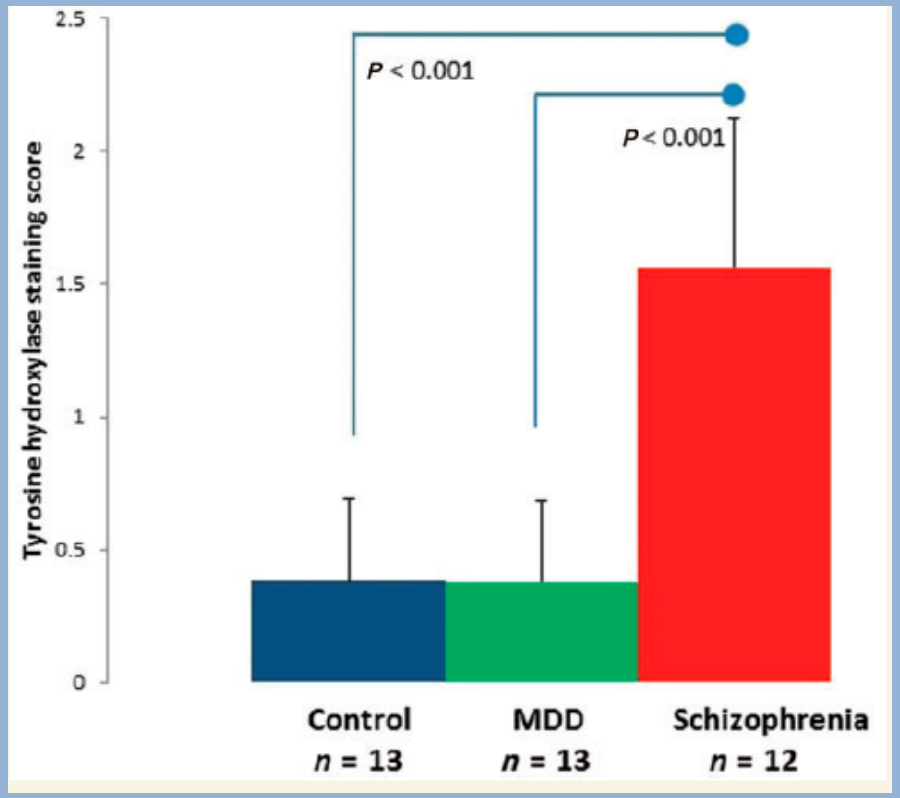
Fig.4. Distribution in the SN of dopaminergic cells labeled by the TH cDNA probe from normal (**a**) and PD (**b**) brains. The positions of the labeled cells are indicated by black points on schematized sections. Note the sharply reduced number of labeled cells in the PD brain.

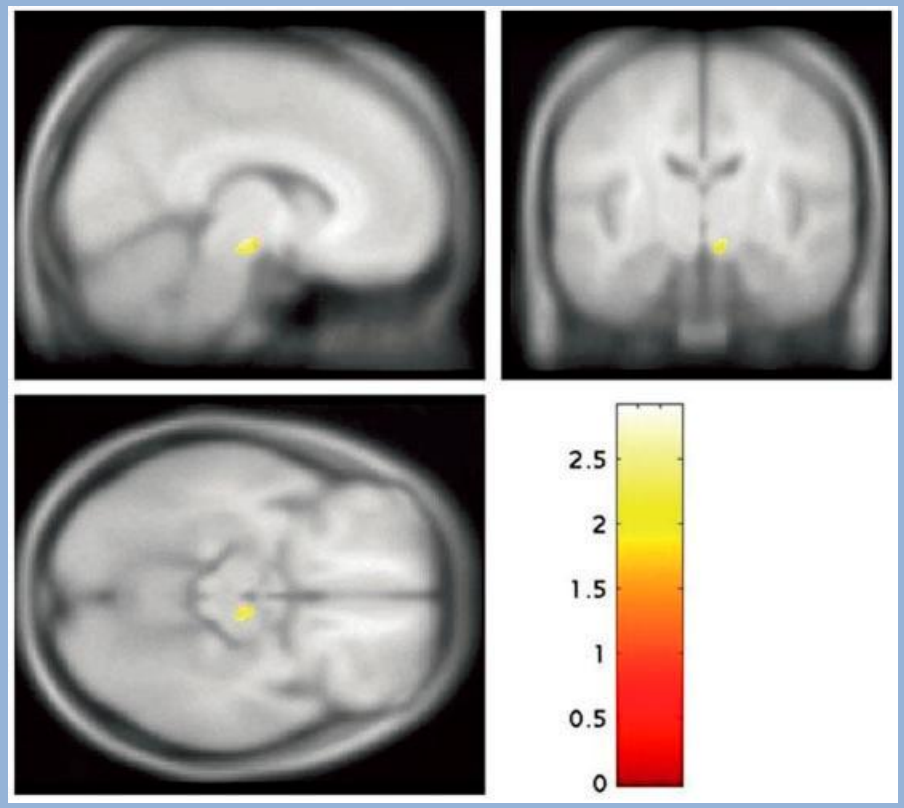
doi:10.1093/brain/awt264 Brain 2013: 136; 3242–3251 | 3242

BRAIN
A JOURNAL OF NEUROLOGY

Midbrain dopamine function in schizophrenia and depression: a post-mortem and positron emission tomographic imaging study

Oliver D. Howes,[1,2] Matthew Williams,[2] Kemal Ibrahim,[2] Garret Leung,[2,3] Alice Egerton,[1,2] Philip K. McGuire[1] and Federico Turkheimer[1]






CHARLIE F.
DEC. 9, 2005
ADDICT

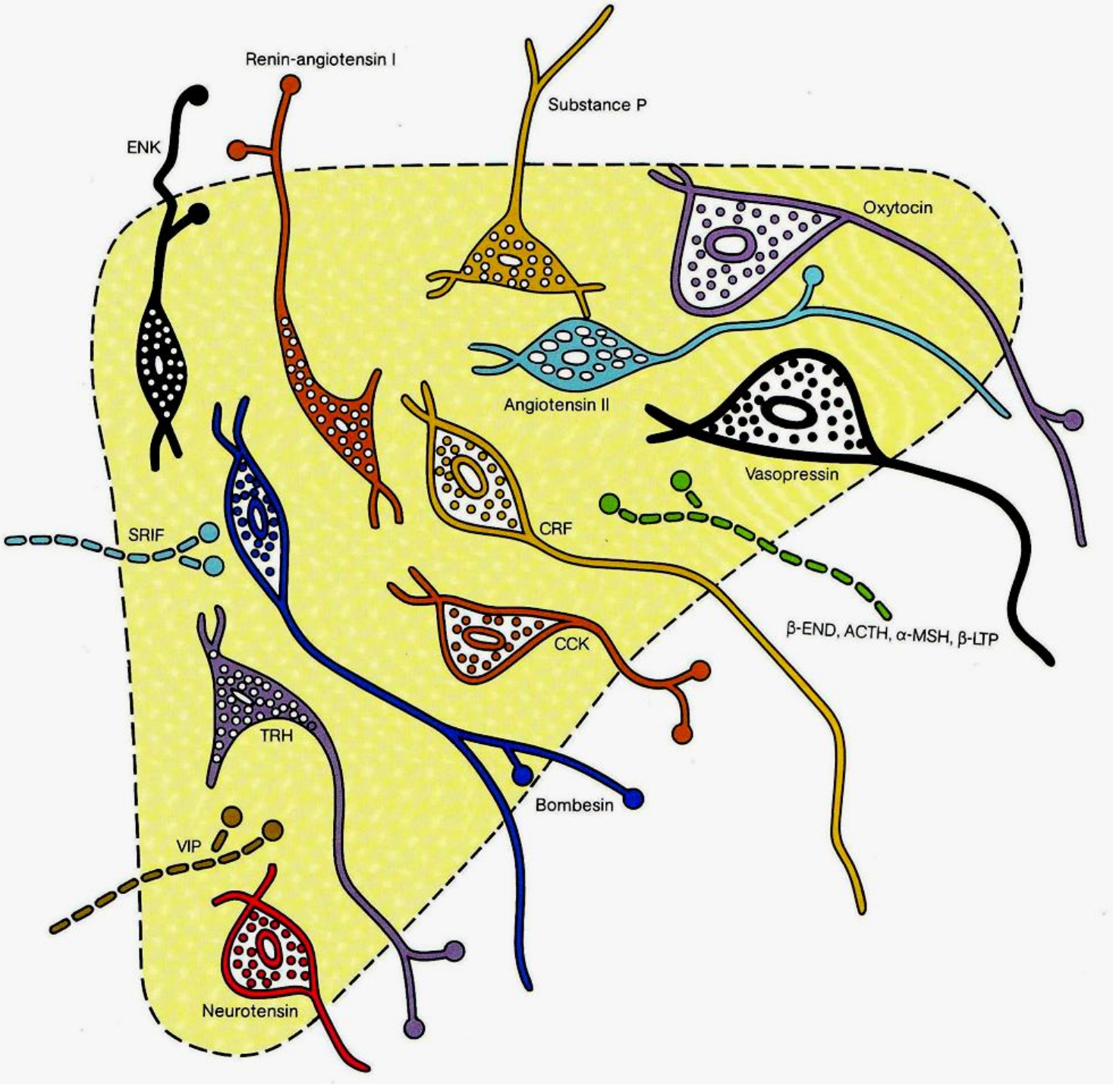
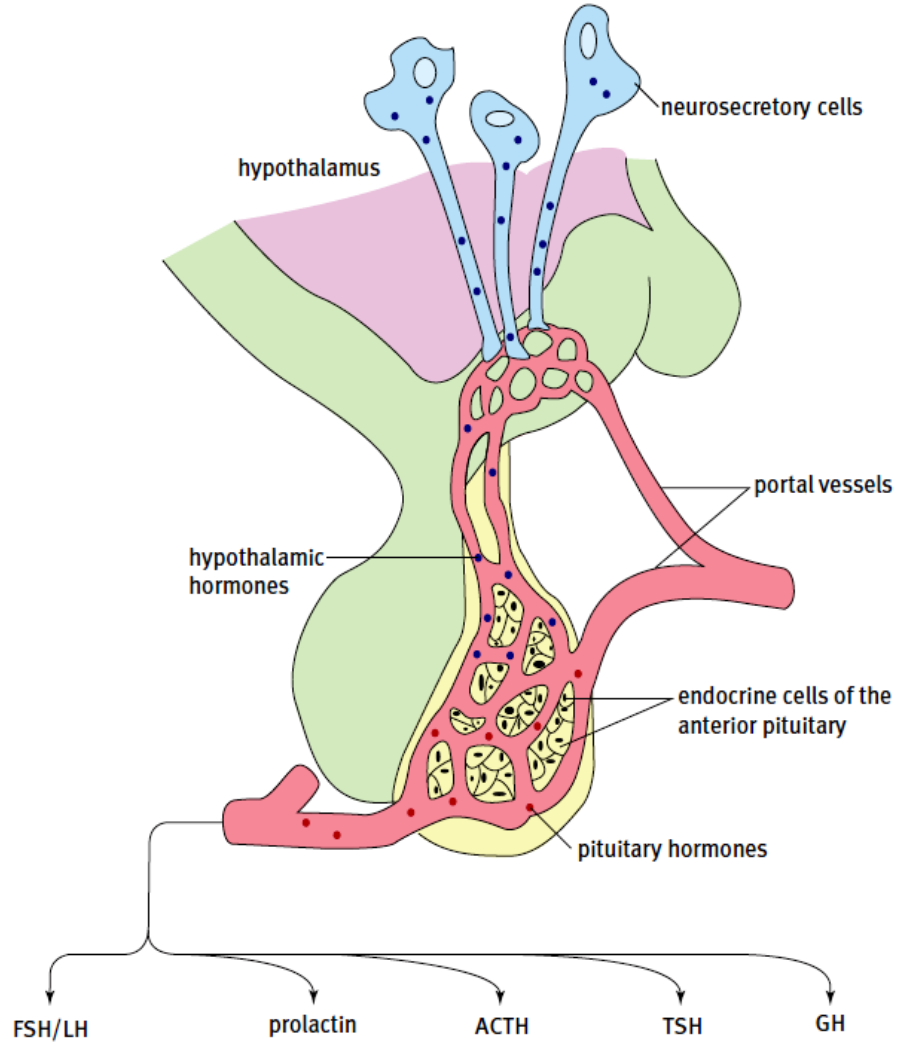
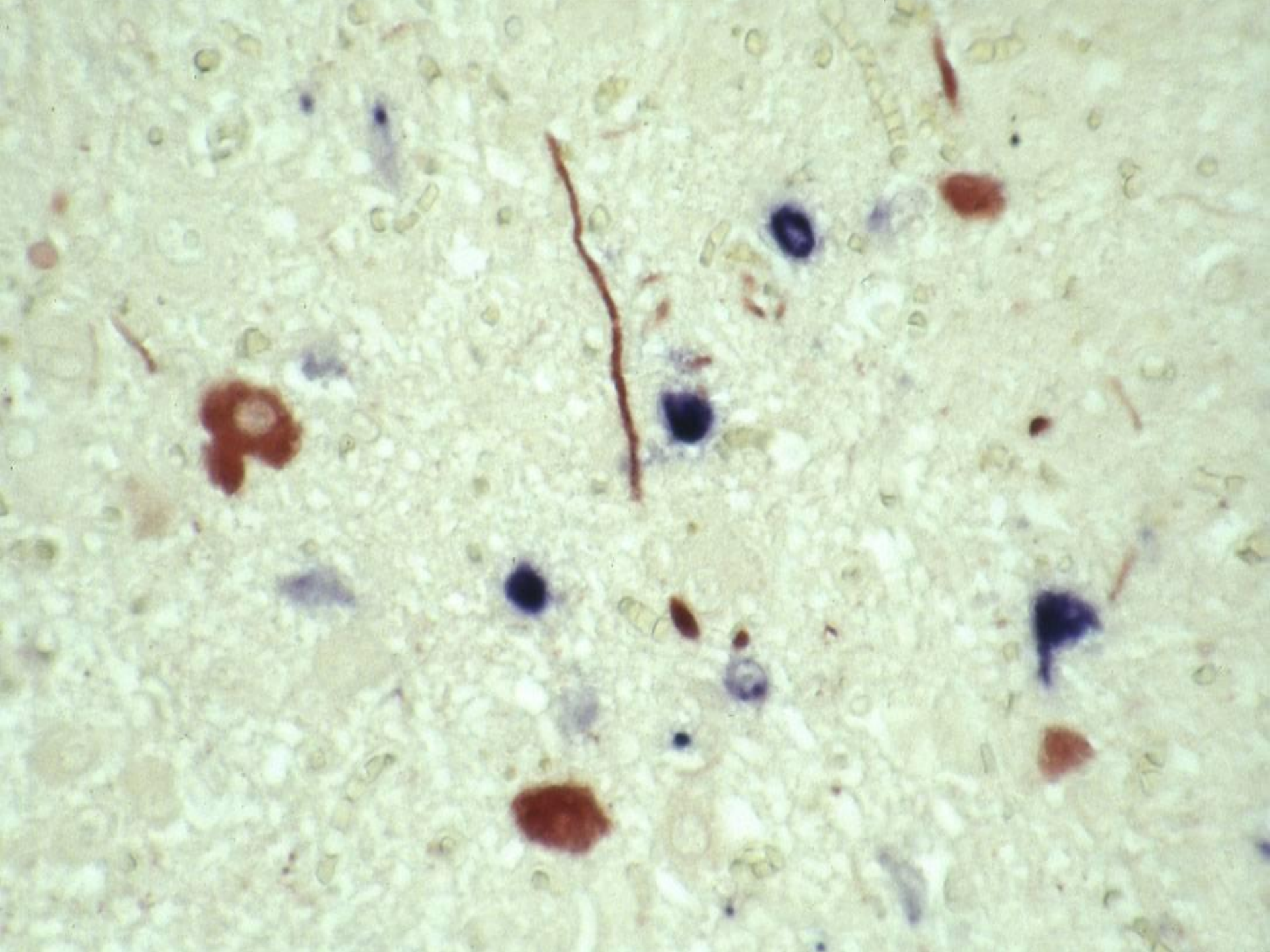

Renin-angiotensin I
Substance P
ENK
Oxytocin
Angiotensin II
Vasopressin
CRF
SRIF
β-END, ACTH, α-MSH, β-LTP
CCK
TRH
Bombesin
VIP
Neurotensin

Figure 5.15 Parvicellular neurosecretory system of the hypothalamus



Small cells in certain nuclei of the hypothalamus secrete releasing factors called hypophysiotrophic hormones. The hormones are released into a capillary network. Small veins from this network carry the hormones to a second capillary network in the anterior pituitary where the hormones trigger the release of the anterior pituitary hormones (FSH, LH, prolactin, ACTH, TSH, GH). (Adapted from Campbell, 1996, p 925)



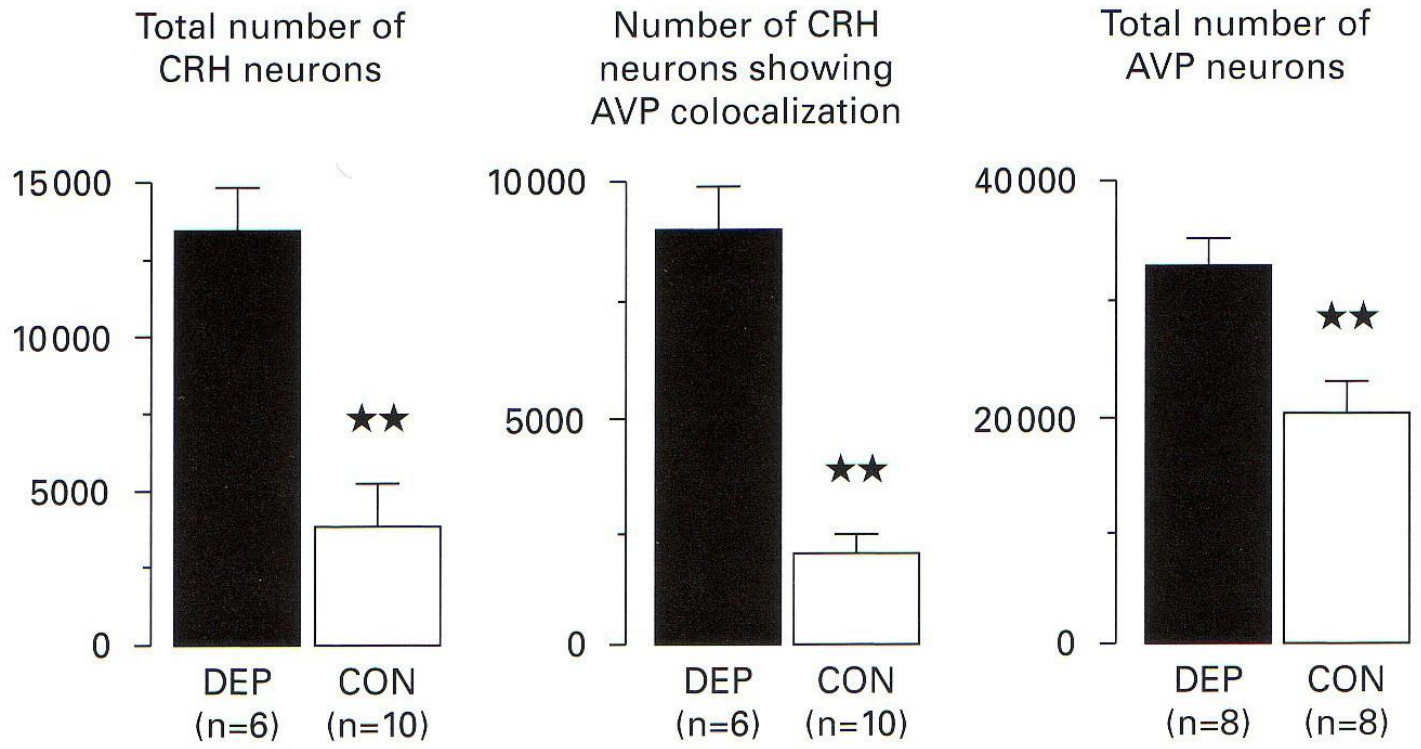


Figure 8.7. Number of CRH and arginine vasopressin (AVP) neurons in the paraventricular nucleus (PVN) of depressed patients. Patients with major depression have an increased number of CRH and AVP neurons and neurons containing both CRH and AVP in the hypothalamic PVN. Both peptides potentiate their actions on pituitary CRH receptors. DEP, depressed patients; CON, controls (adapted from Raadsheer *et al.*, 1994; Purba *et al.*, 1996; Holsboer, 1999).

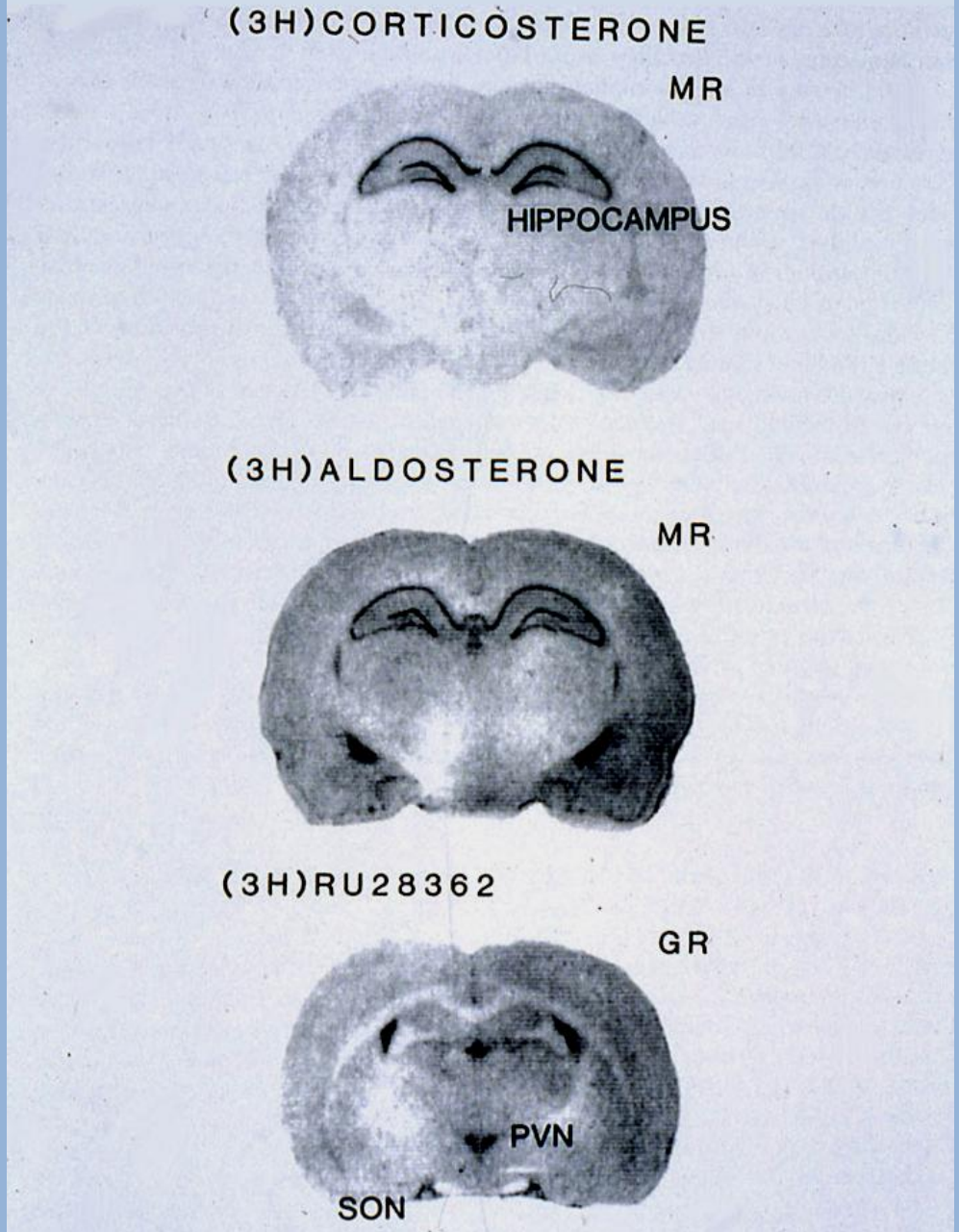


Figure 1.1 Localization of MR and GR in the brain. Tracer amounts of [^{3}H]-aldosterone, [^{3}H]-corticosterone and the pure glucocorticoid [^{3}H]-RU28362 were administered to adrenalectomized rats. One hour after administration the rats were killed and autoradiograms were generated. Note retention of aldosterone and corticosterone by hippocampal neurons, and of RU28362 by the PVN.

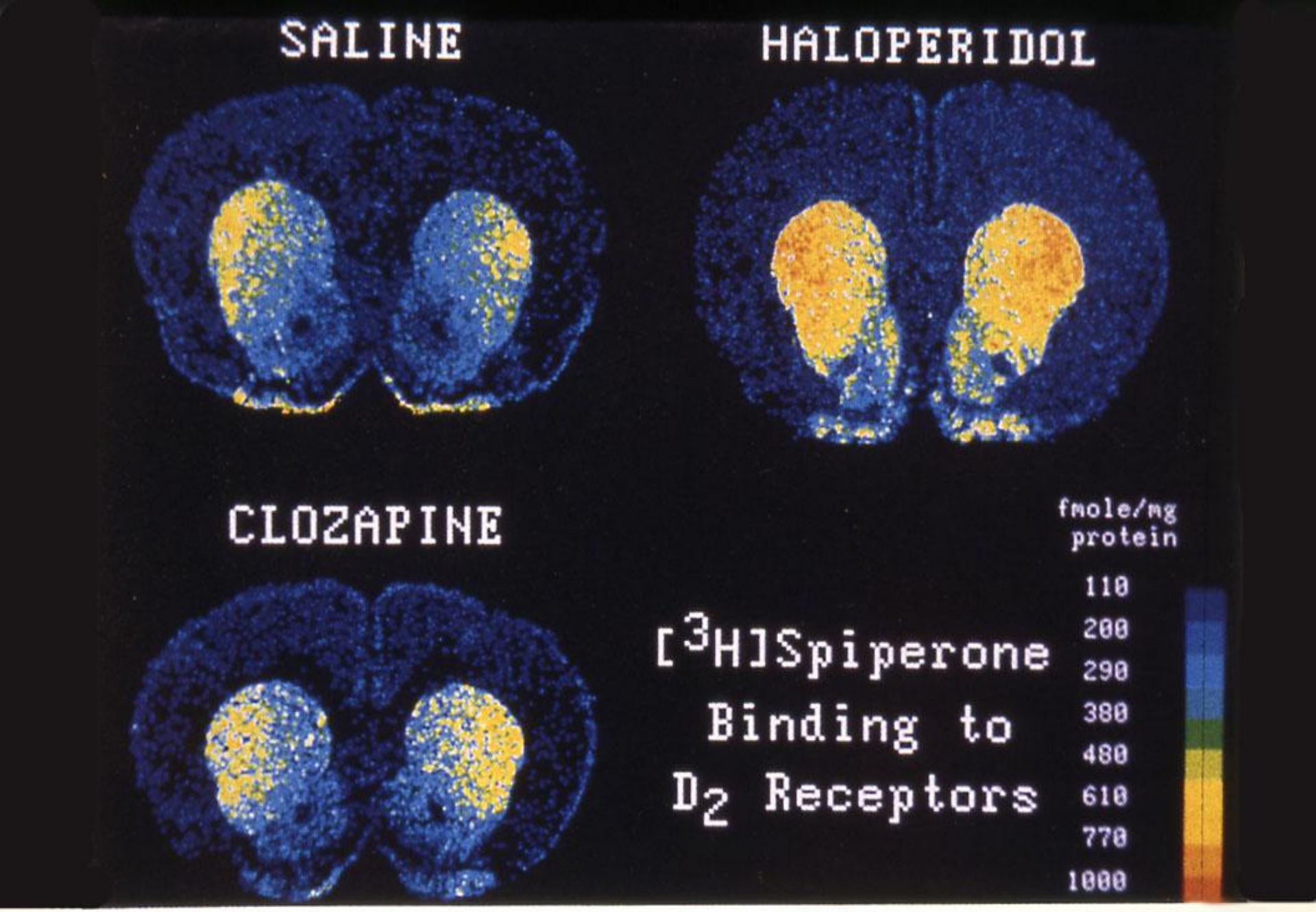


FIG. 1. Autoradiographs showing increased dopamine D_2 receptor binding in all regions of the caudate putamen following chronic administration of haloperidol but not of clozapine.