Split, February 29, 2016

PRINCIPLES OF NEURAL SCIENCE

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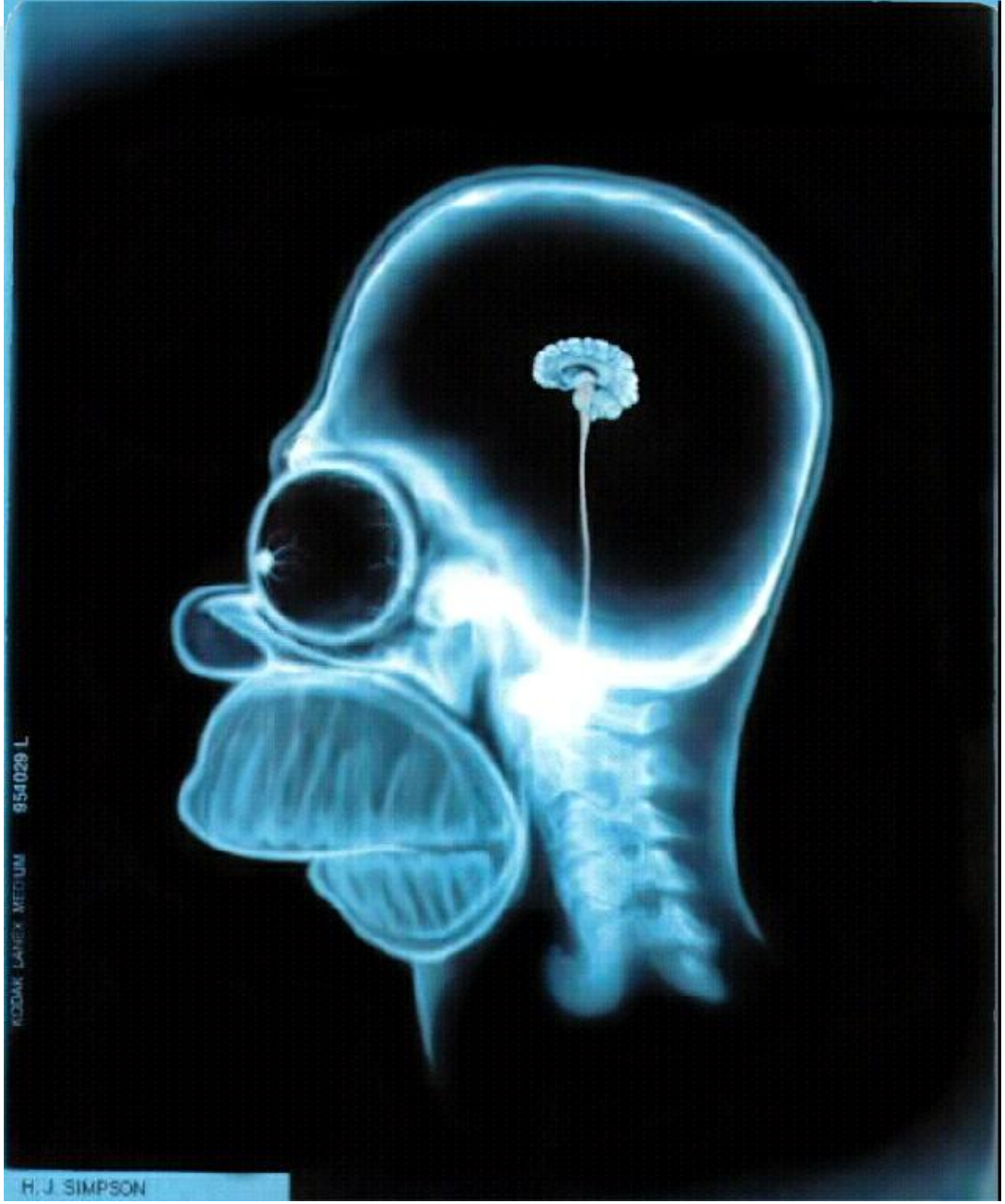
Director of the Sleep Medicine Center, MEFST, Split and University Hospital Split
Croatian Somnological Society, President
European Sleep Research Society, past Board Member and Education Committee Chair

University of Split, School of Medicine; Department of Neuroscience

LECTURE OUTLINE:

- ***About the brain...***
- ***Neuroscience***
- ***Cellular structure of CNS (and cortex)***
- ***Communication in the brain***
- ***Neurotransmitters and receptors***
- ***Brain plasticity***


KODAK LANEX MEDIUM 85029 L
H. J. SIMPSON

...

March 11-17, 2013

March 10-16, 2014

March 16-22, 2015

March 14-20, 2016

O tell me where is fancy bred

Or in the heart, or in the head

William Shakespeare

Egyptian hieroglyphics for the word "brain"

17th century B.C.

The earliest known reference to the human brain

Hippocrates and Plato

among others:

There is something special about the brain

The brain is responsible for behaviors in human and other animals

Understanding the biology of brain function is a major goal of modern science

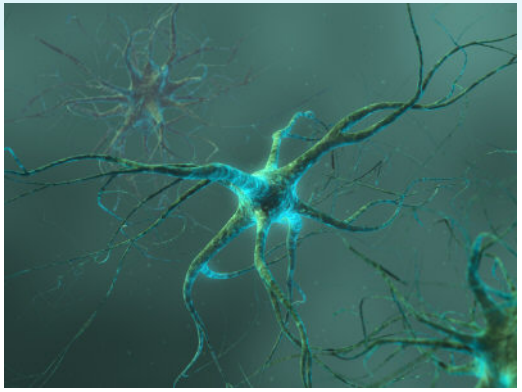
CURRENT VIEWS OF NERVE CELLS, THE BRAIN AND BEHAVIOR

- **Anatomy** Camillo Golgi, Santiago Ramón y Cayal
- **Embryology** Ross Harrison
- **Physiology** Galvani, Du-Bois-Reymond, Mueller, von Helmholtz
- **Pharmacology** Claude Bernard, Paul Ehrlich, John Langley
- **Psychology** René Descartes, David Hume, John Locke

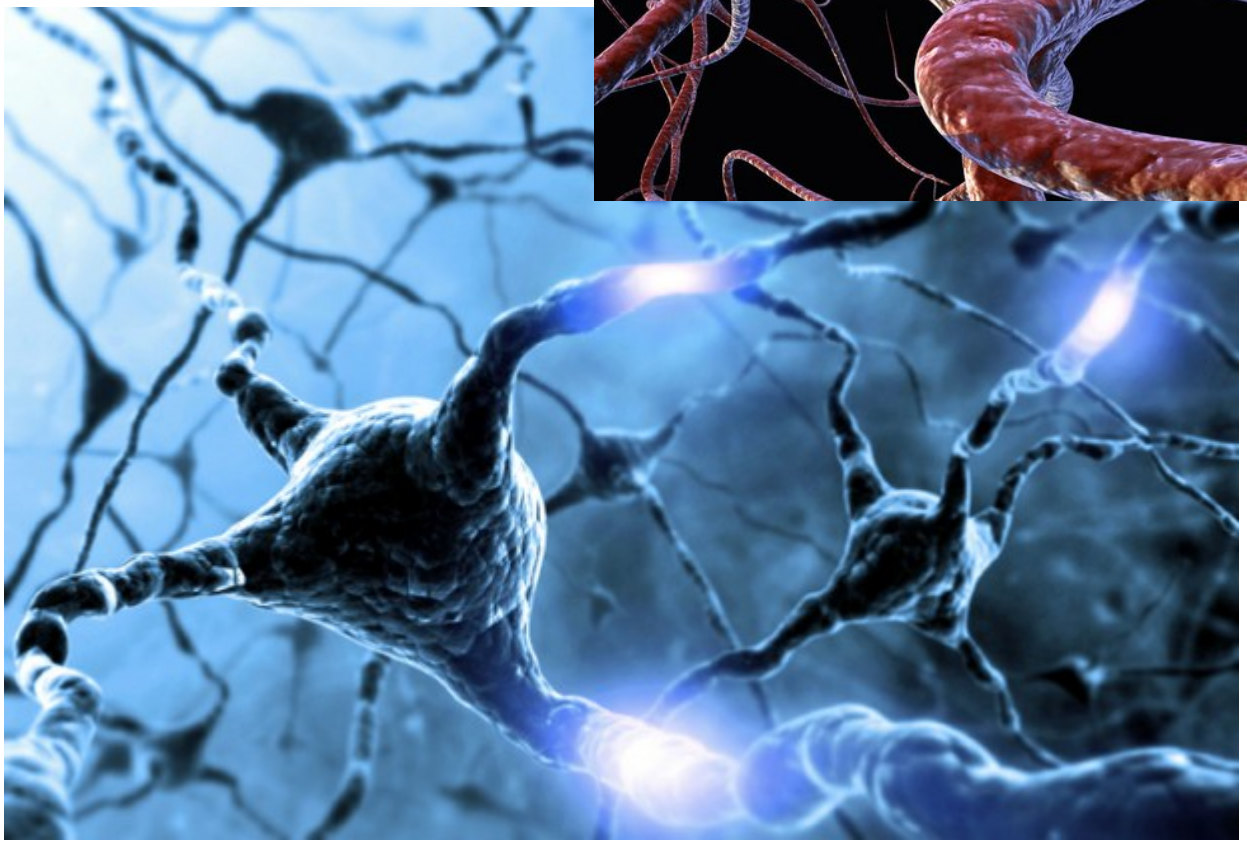
- **Franz Joseph Gall:** **Functions of the mind have a biological basis**

A fundamental goal of neuroscience

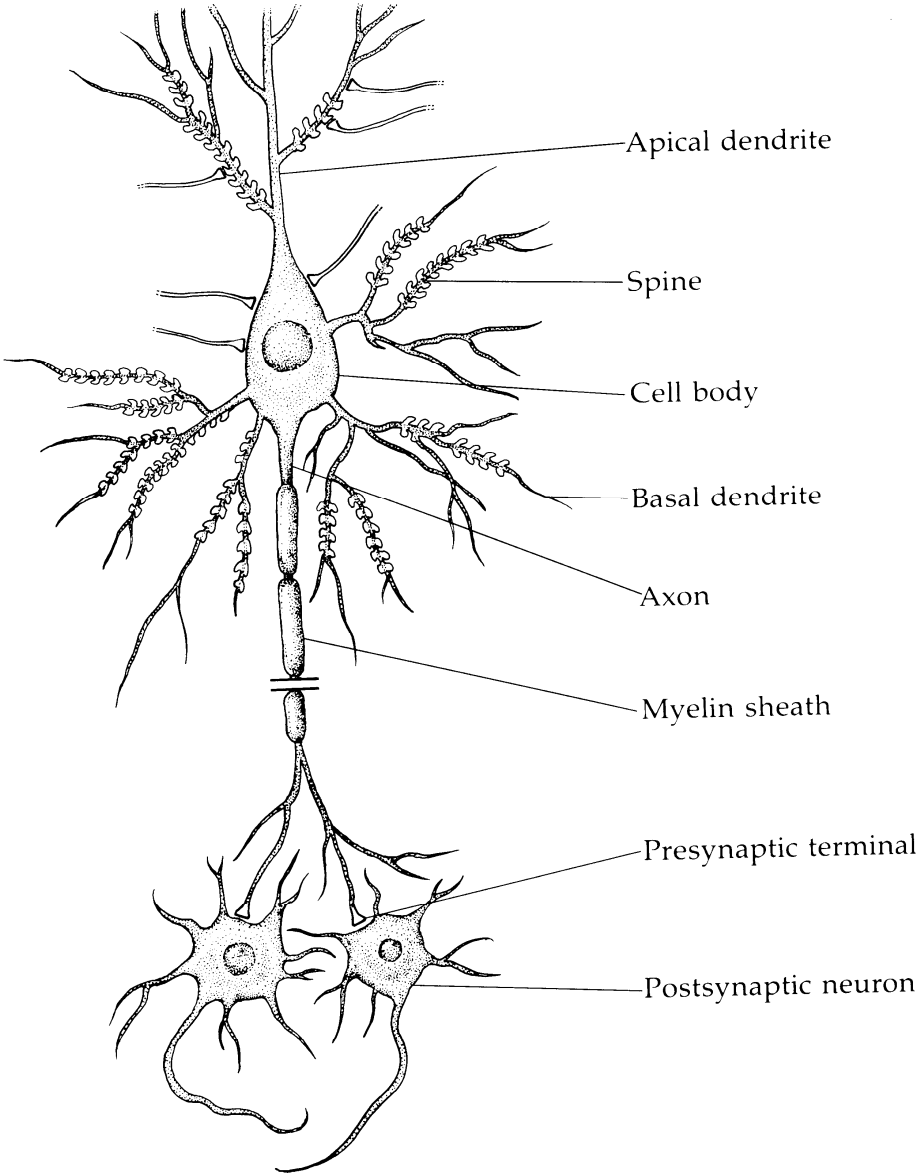
- To understand the way neurons generate animal behaviors



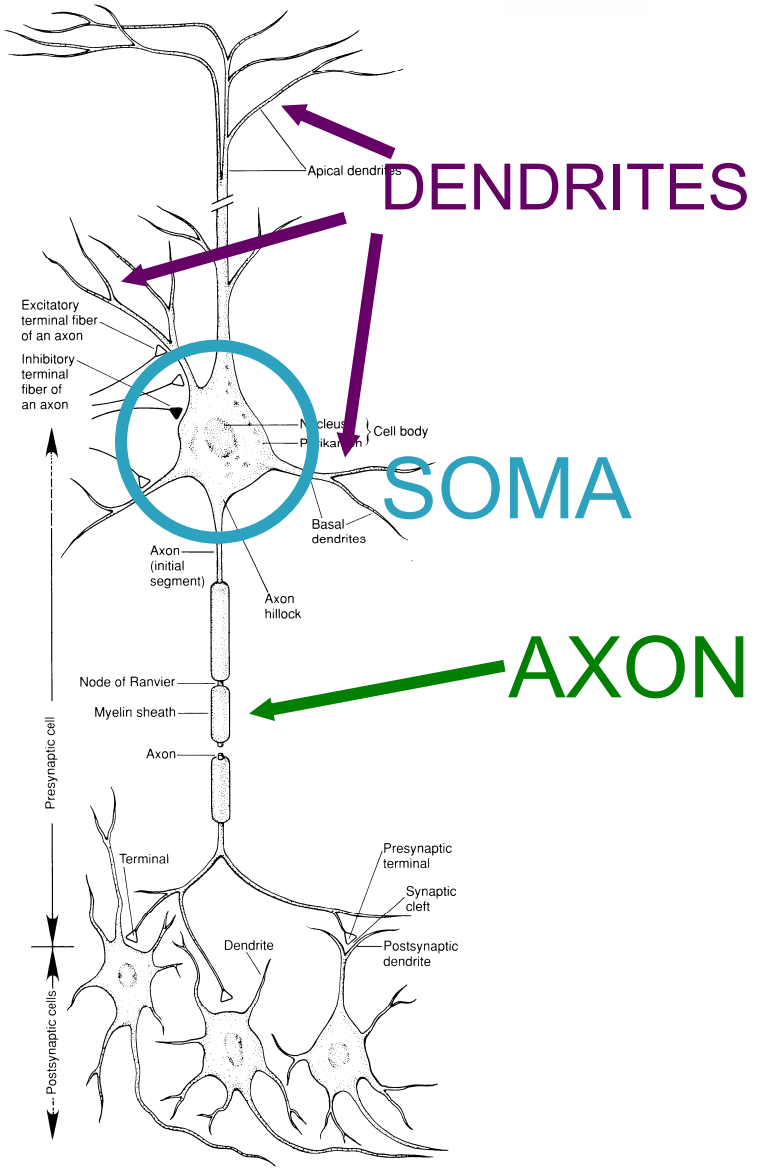
neurons



A neuron and its parts

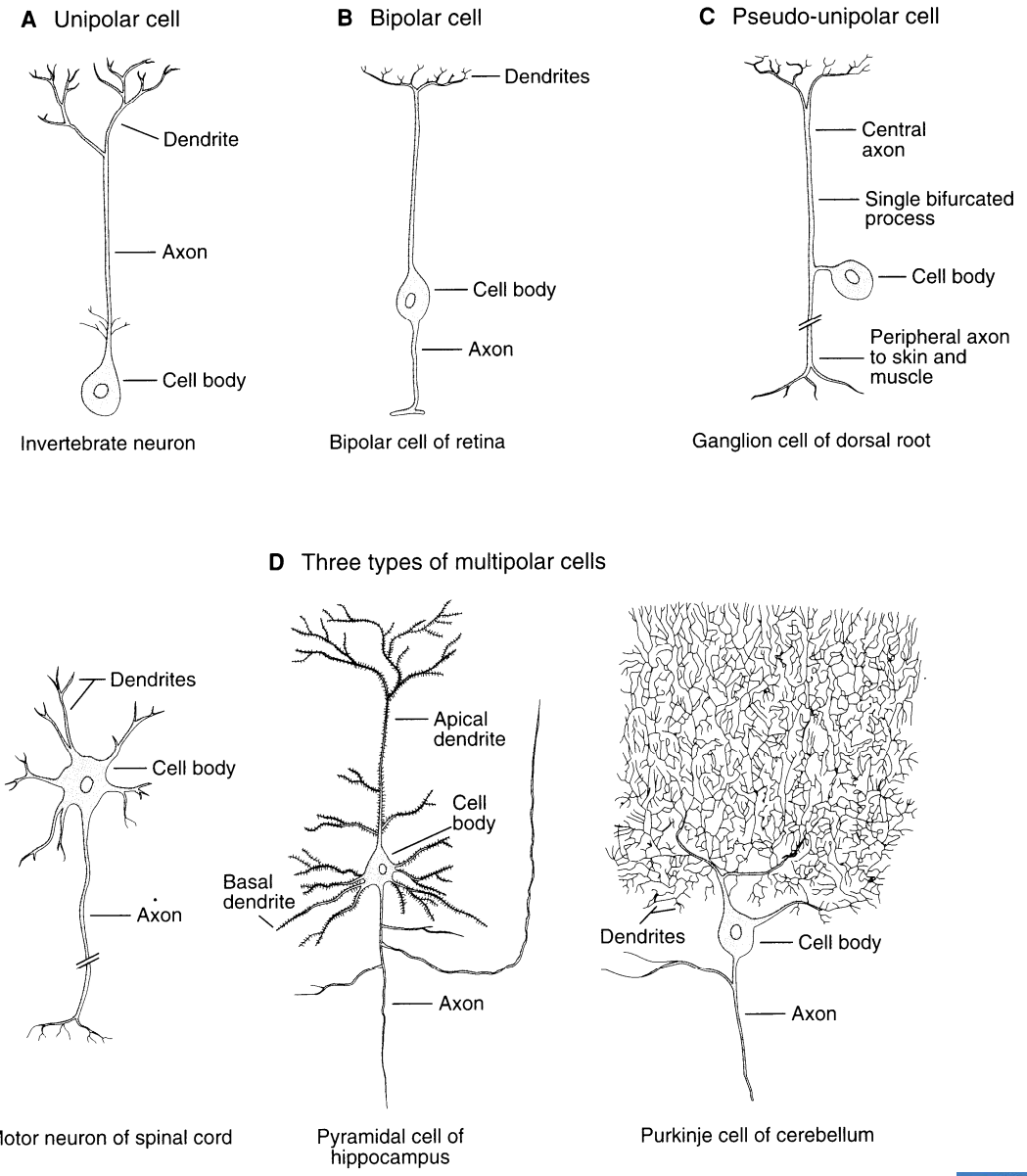


Pyramidal neuron of vertebrates

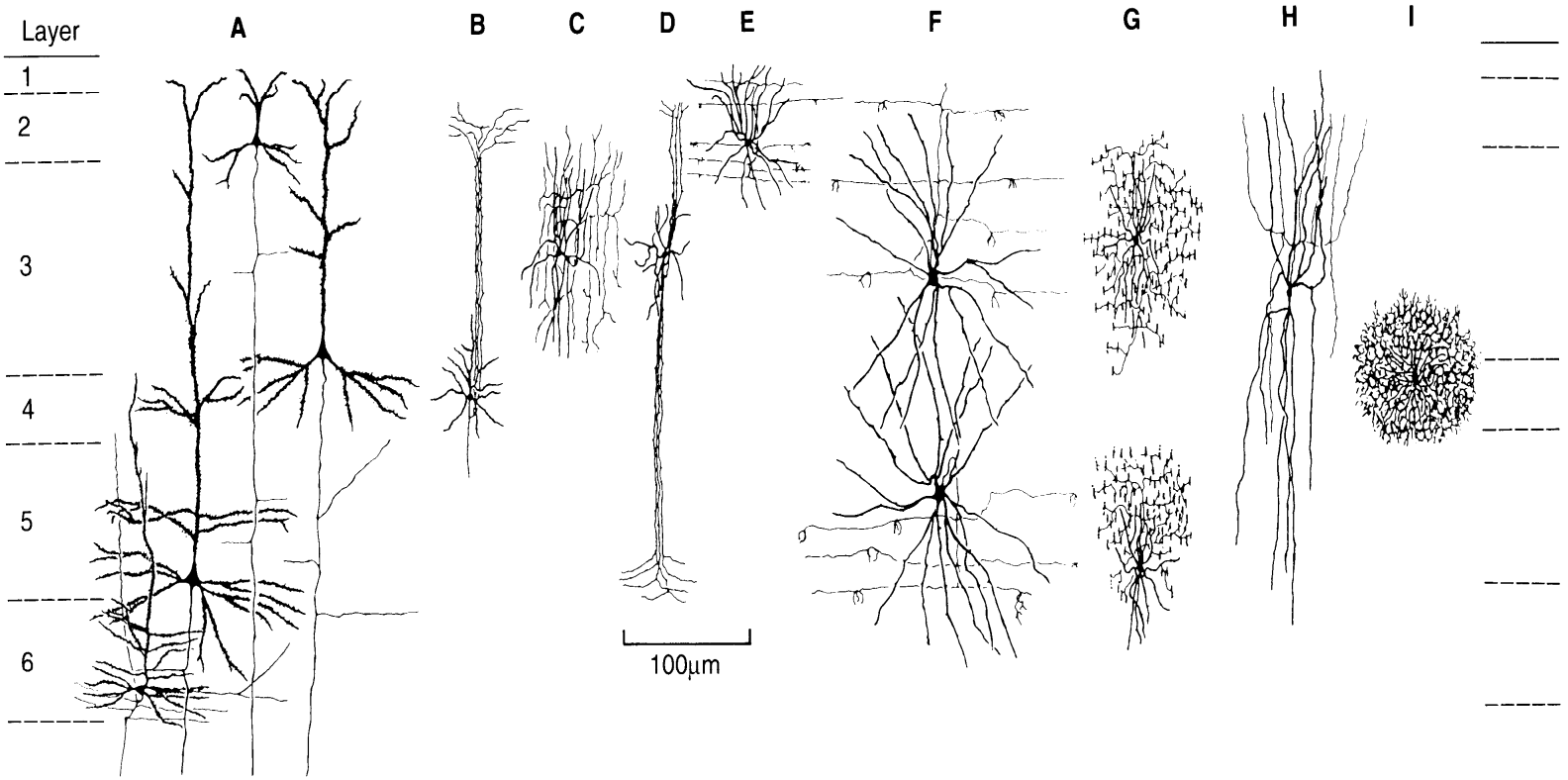


axonal branches make synapses with around 1.000 other neurons

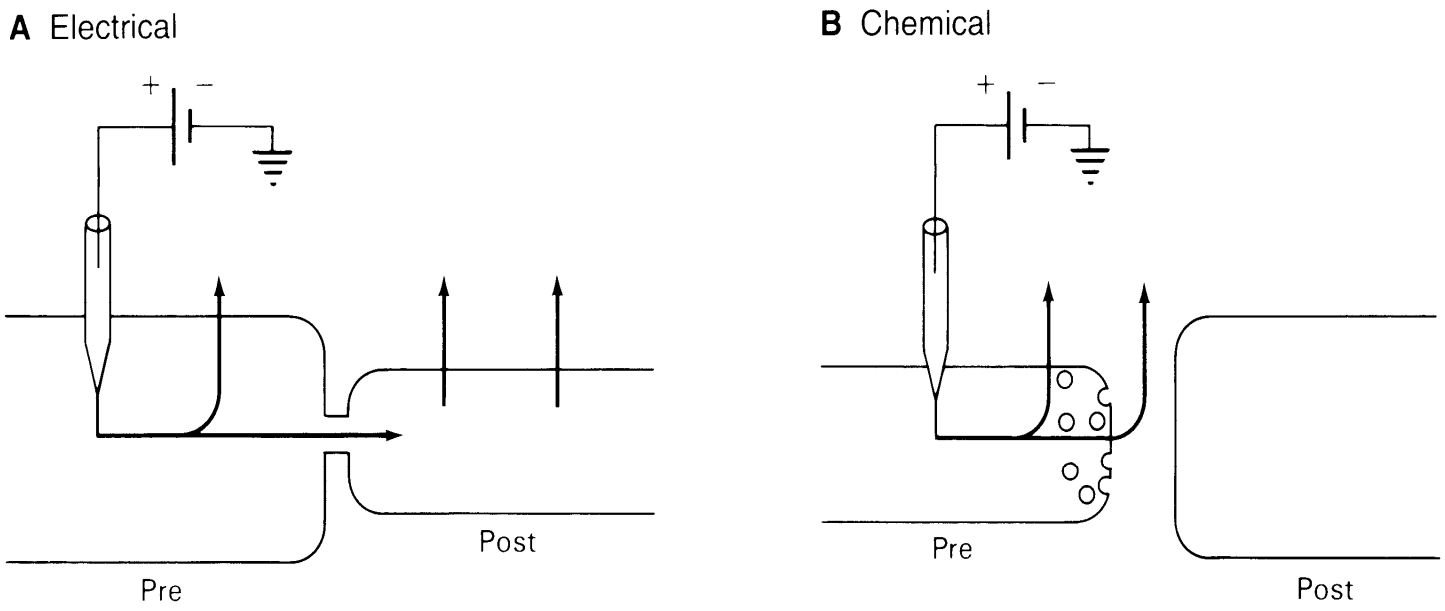
Classification according to the number of processes that originate from the cell body



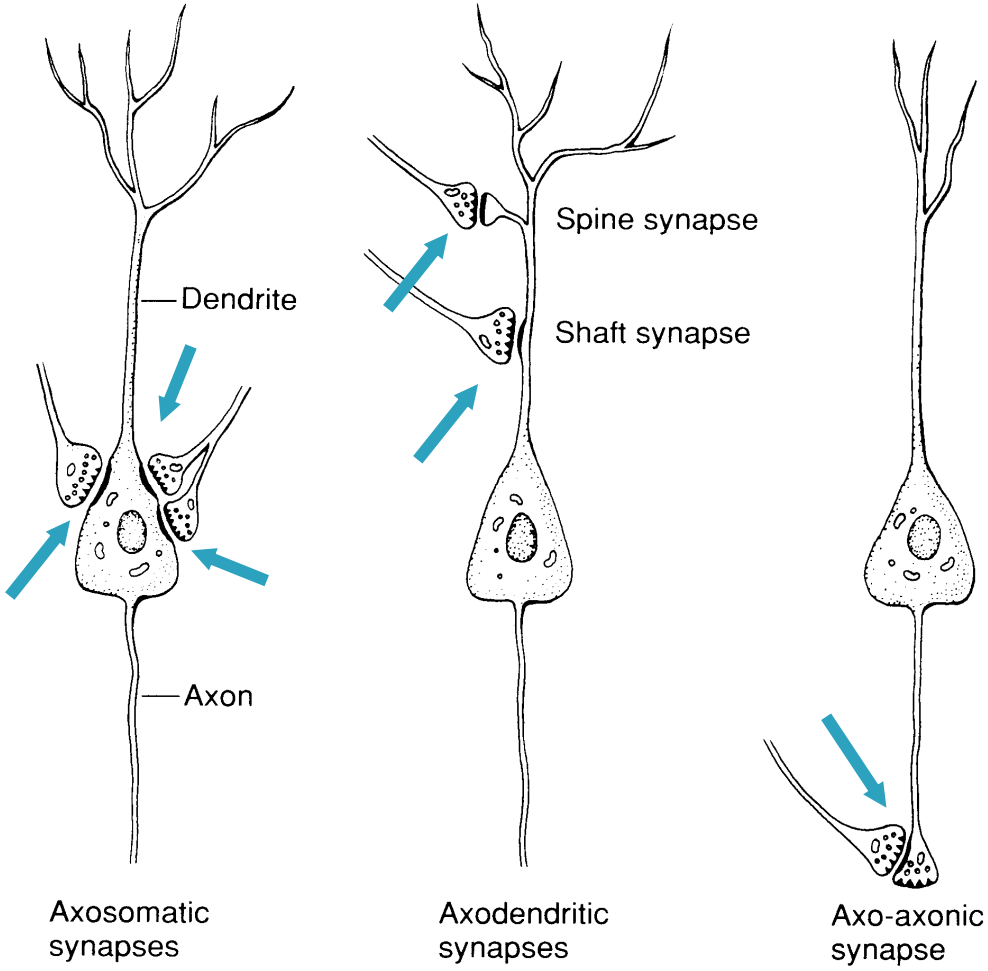
Cerebral cortex neurons



Synapse



Examples of synaptic connections



COMMUNICATION IN THE BRAIN (SIGNALIZATION)

Action potential

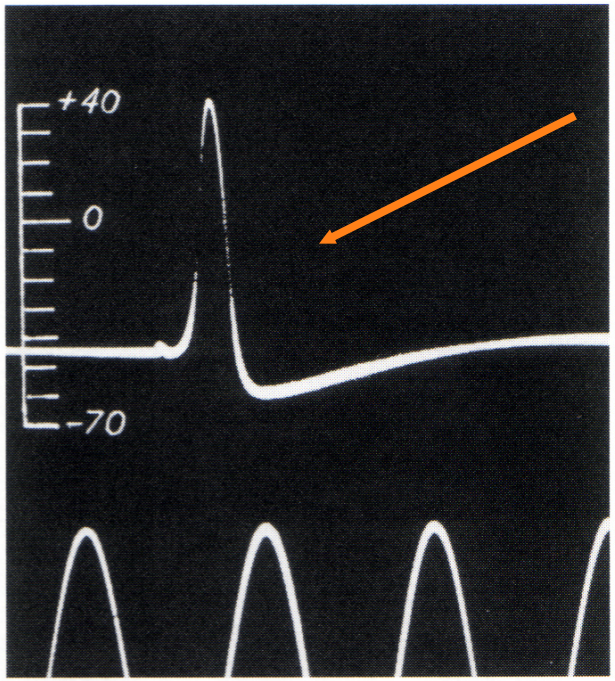
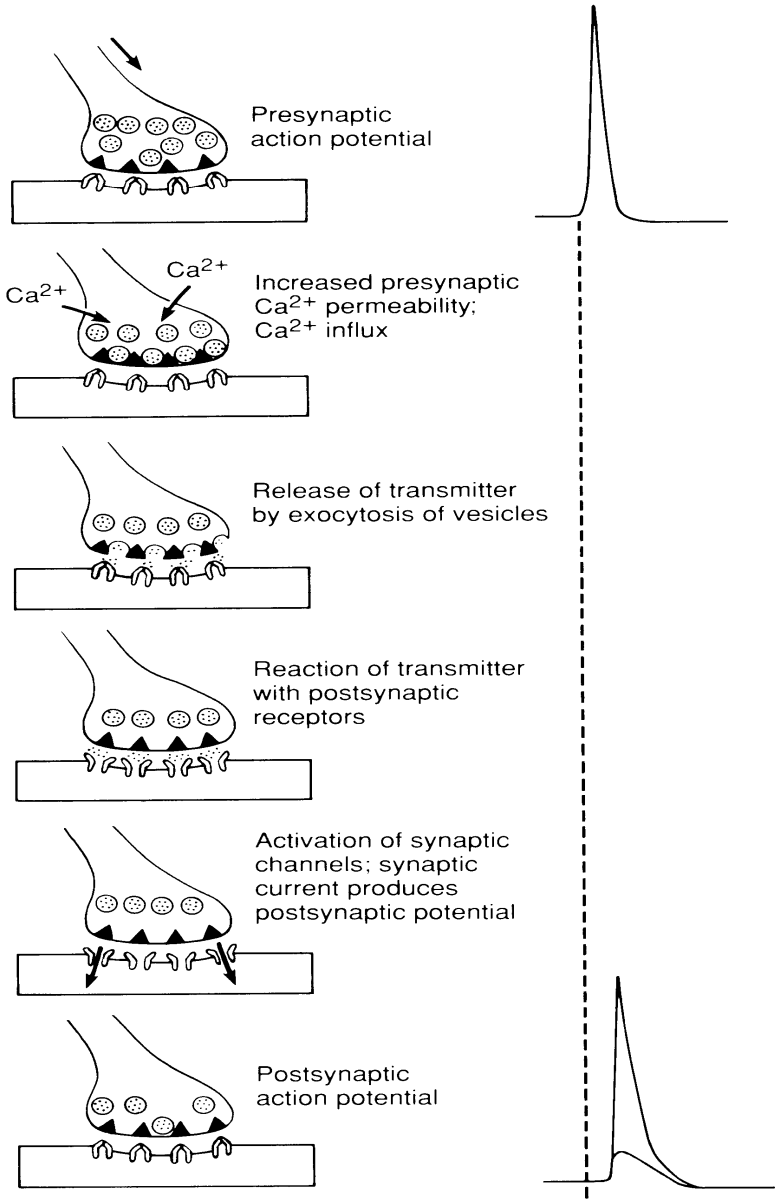
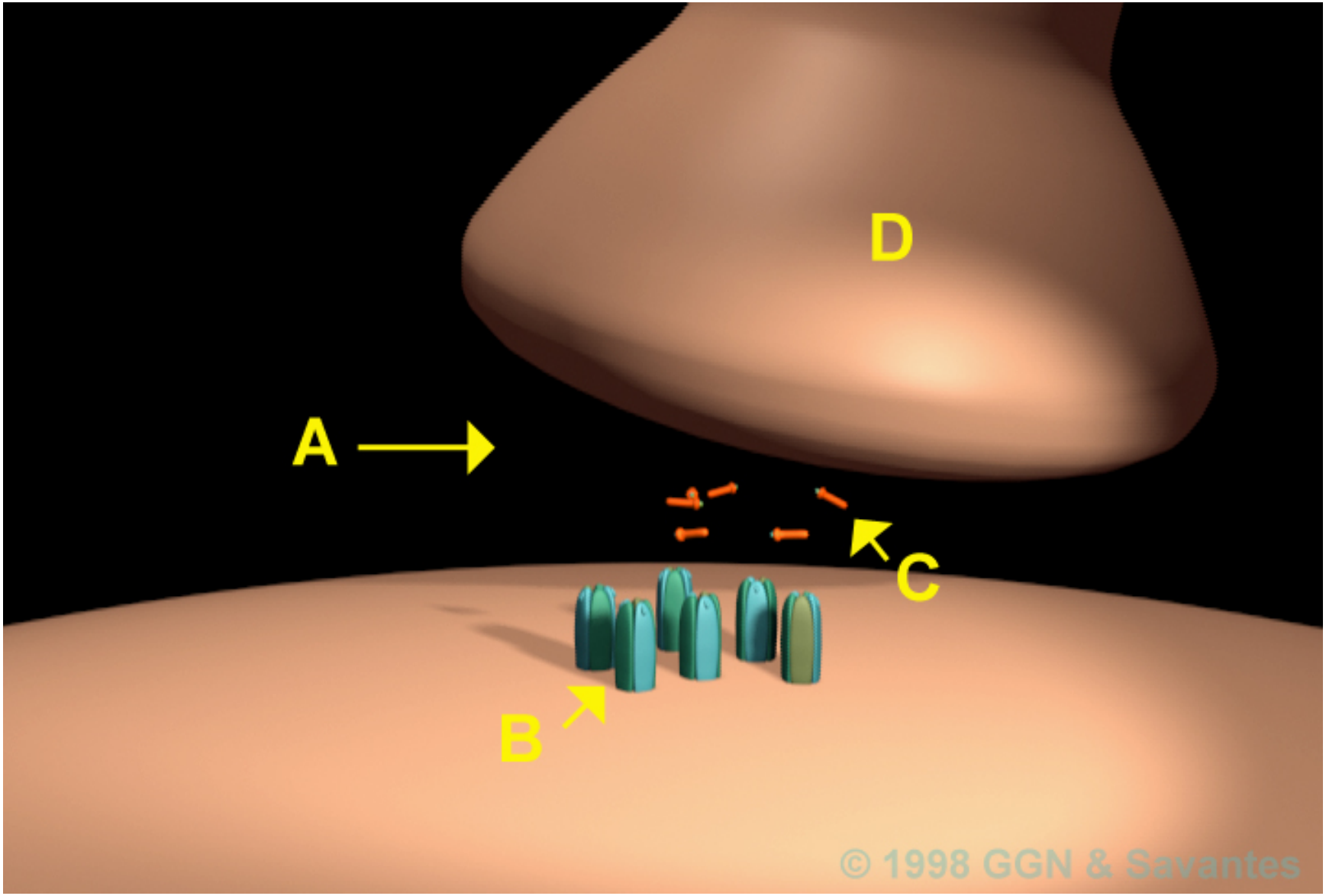


Figure The action potential and resting potential as recorded with a capillary pipette across the membrane of the squid giant axon in a bathing solution of seawater. Time marker on the horizontal axis is 500 Hz. The vertical scale indicates the potential of the internal electrode in millivolts; the sea water outside is taken as zero potential. (From Hodgkin and Huxley, 1939.)

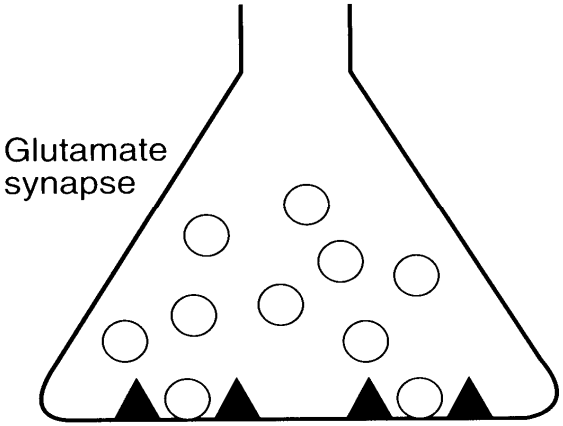
Events during the "talk" of the two neurons



Synaptic connection

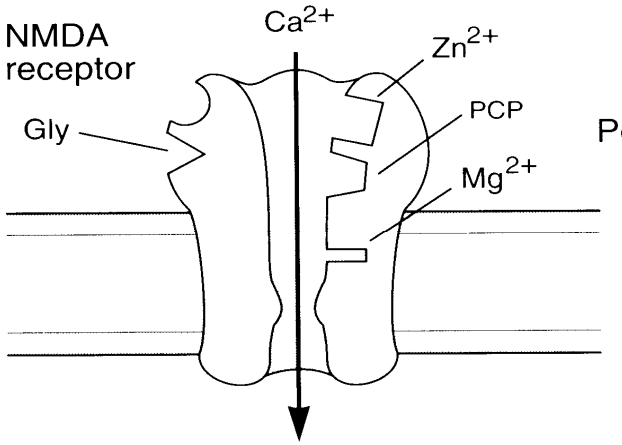


glutamate synapse and NMDA receptor



Presynaptic

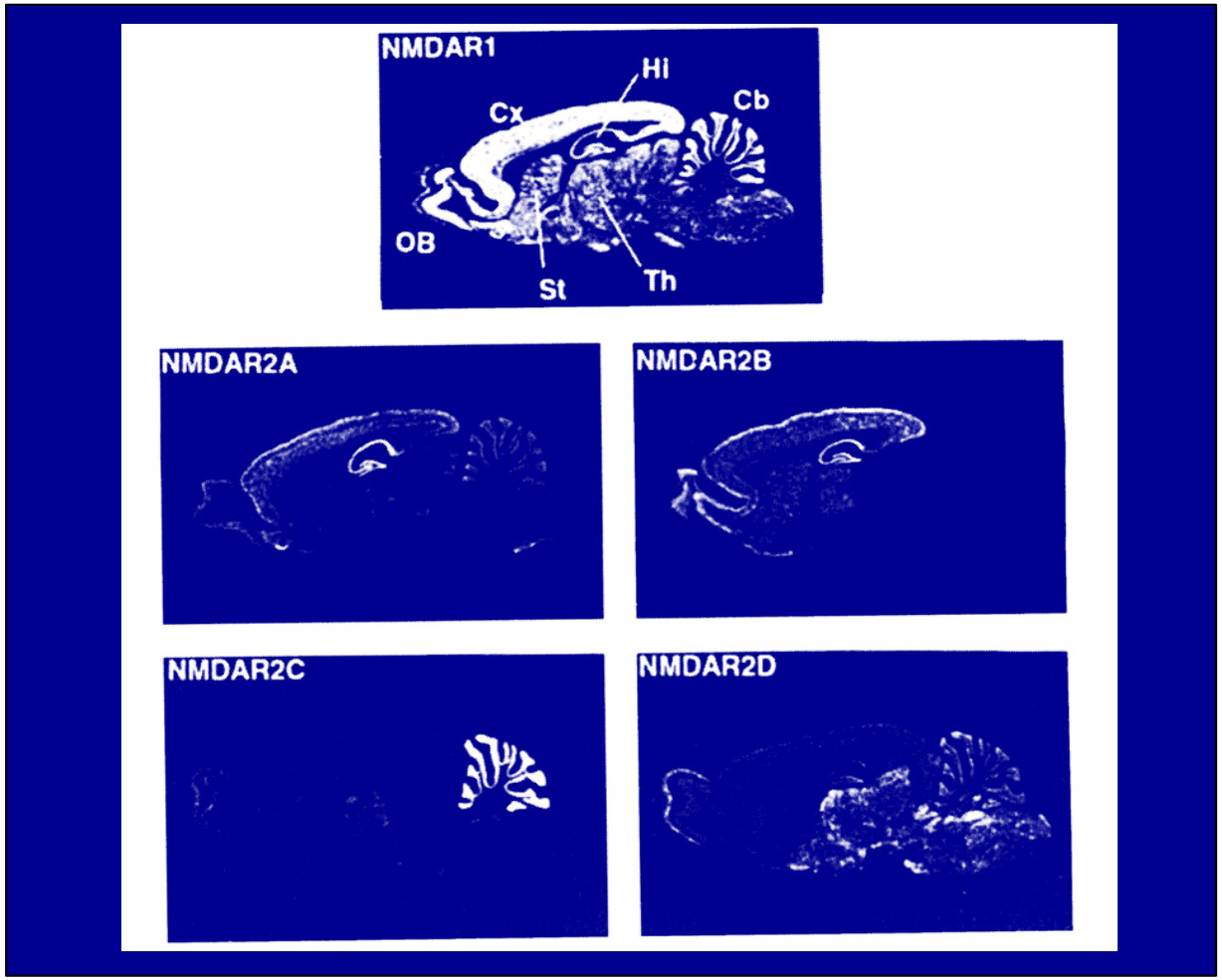
- Increased firing rate
- Increased release
- Decreased uptake



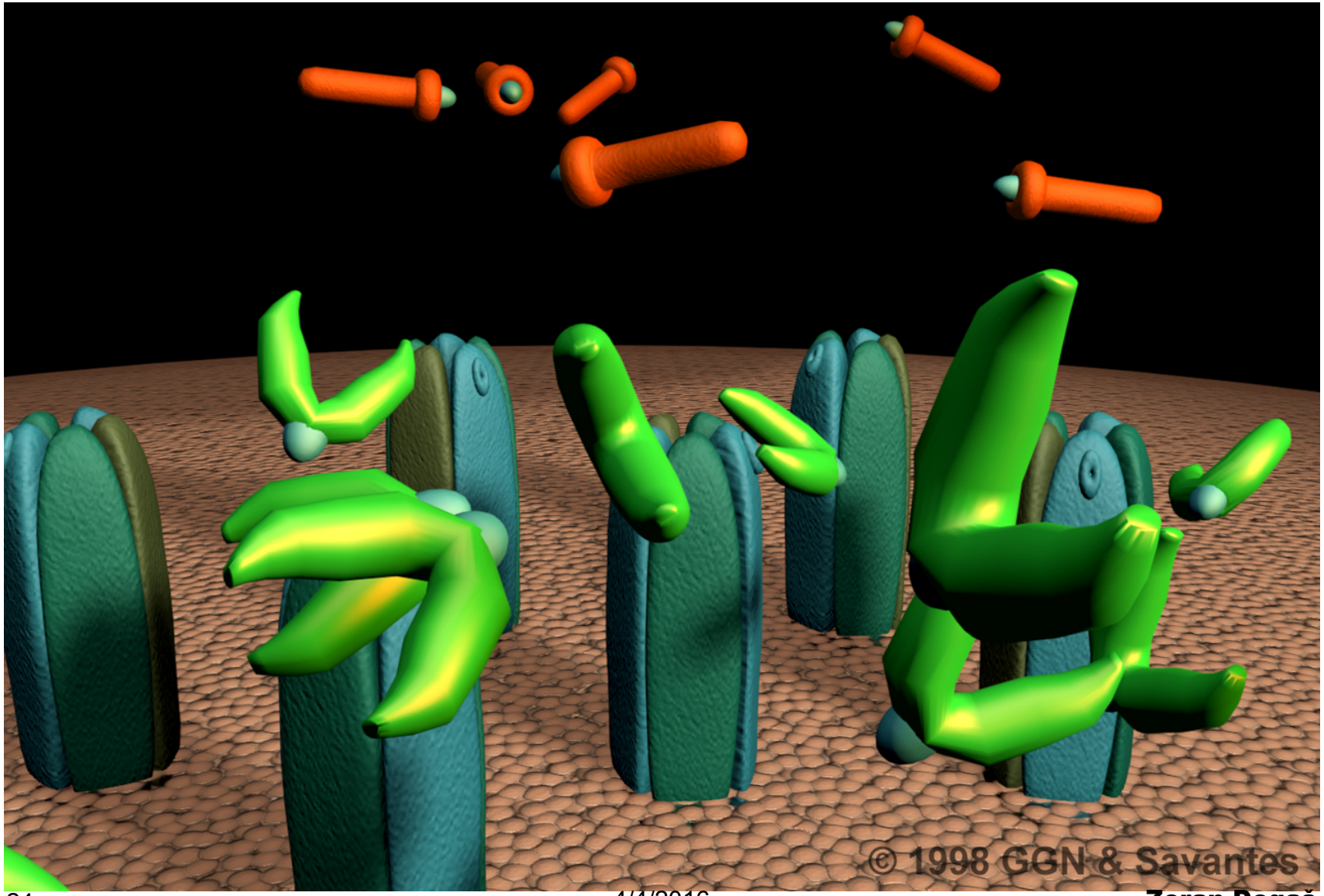
Postsynaptic

- Increased number of NMDA receptors including some abnormal receptors
- Decreased resting potential
- Increased vulnerability to calcium

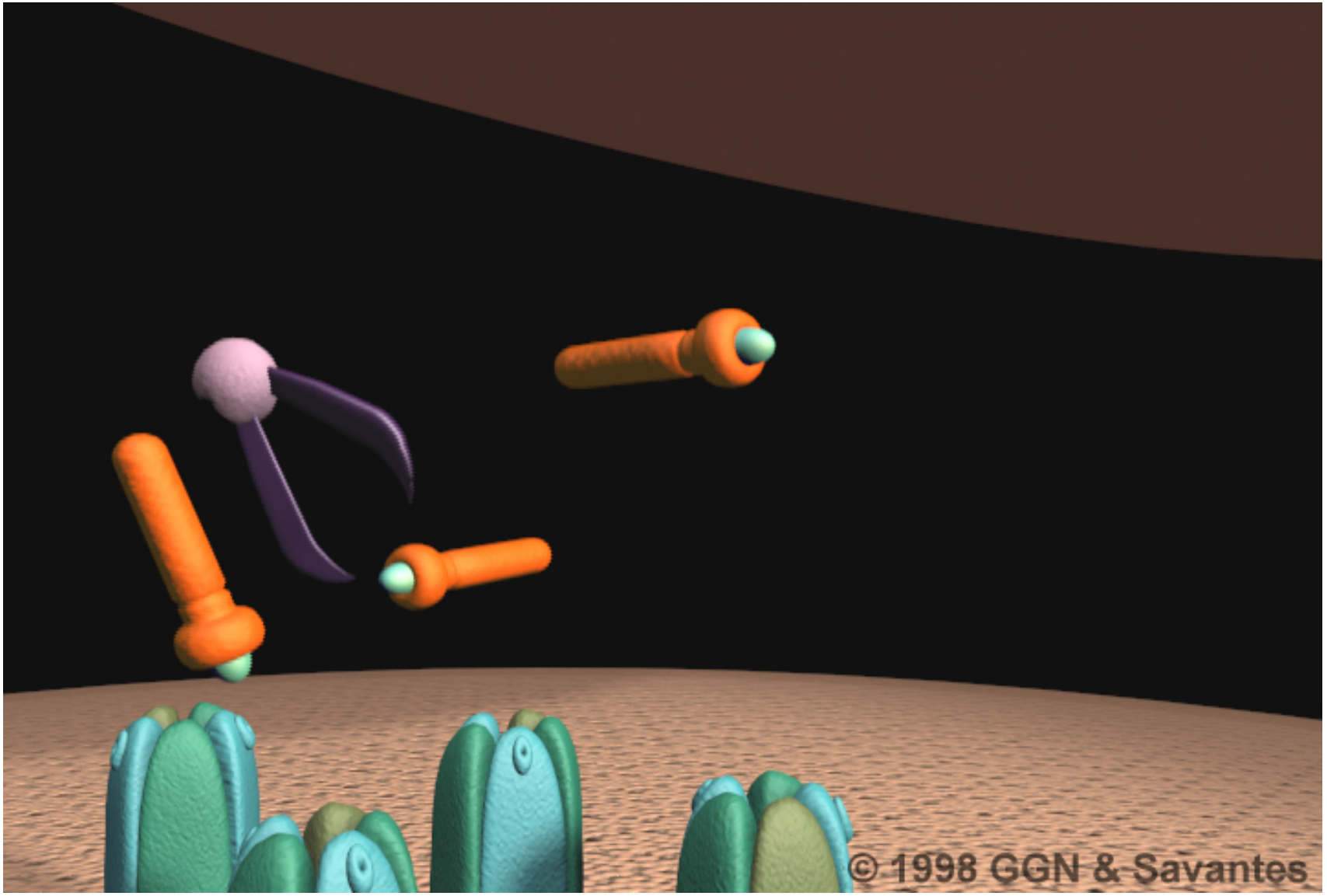
Regional distribution of receptors



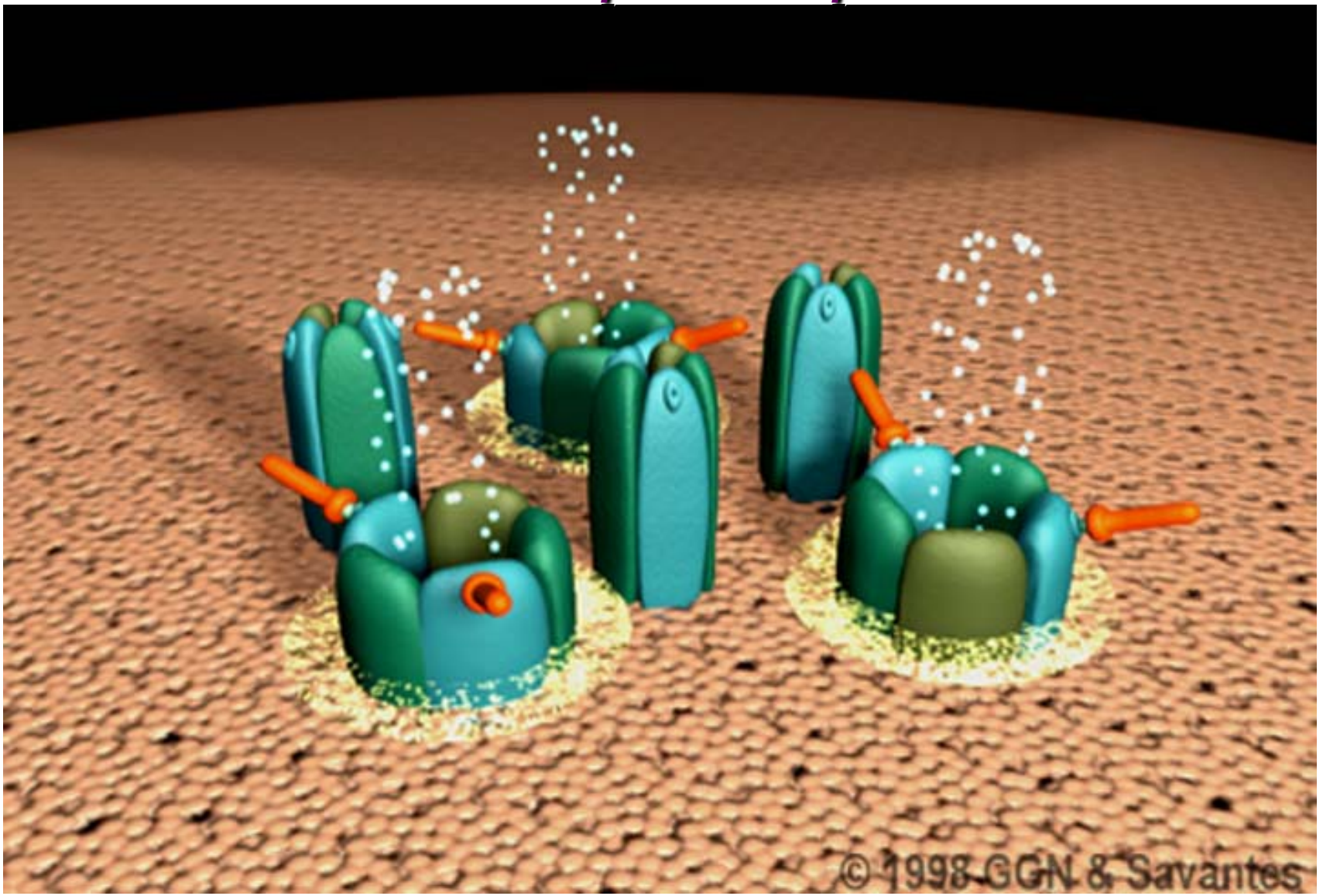
Acetylcholine nicotinic receptor

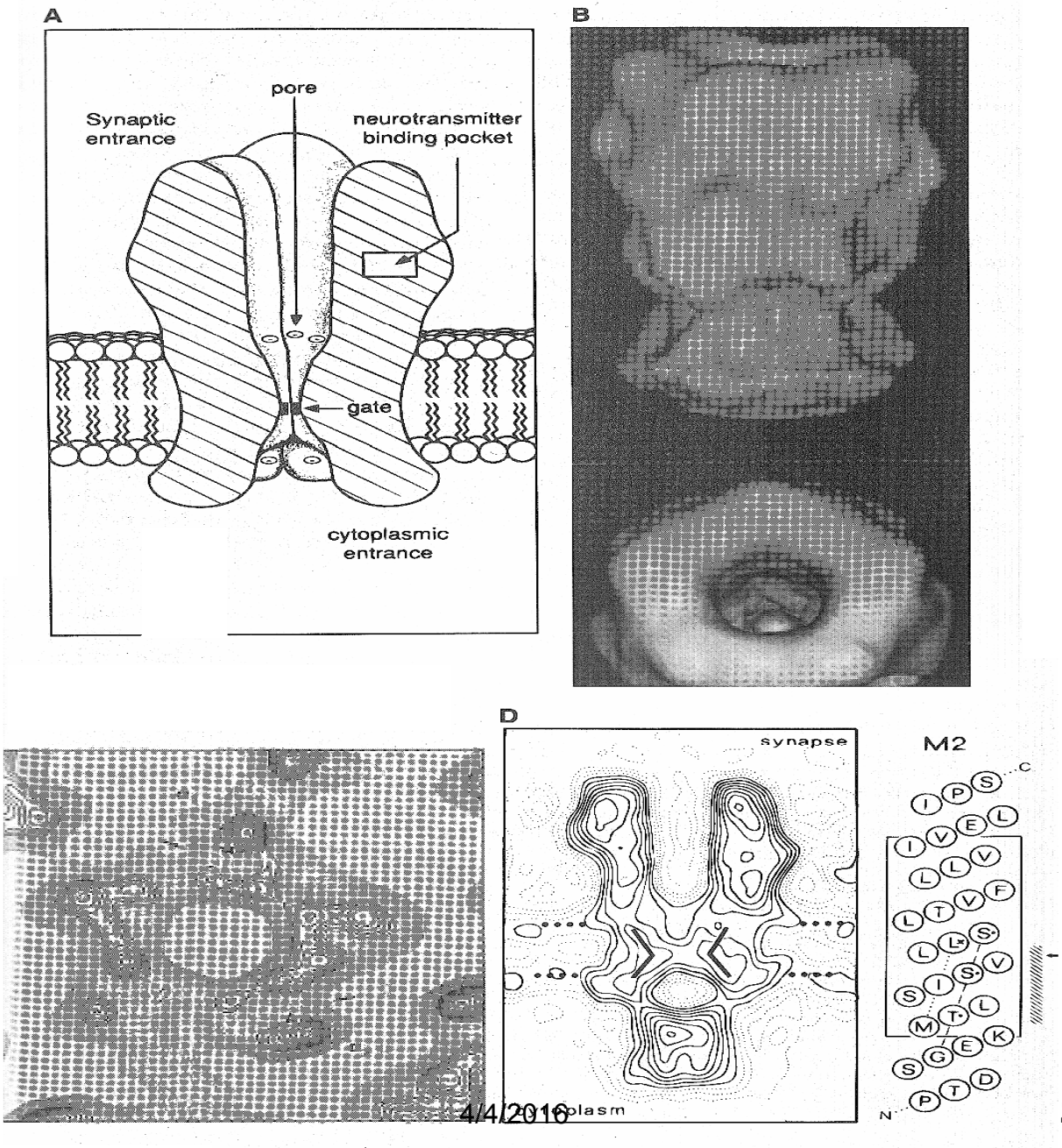


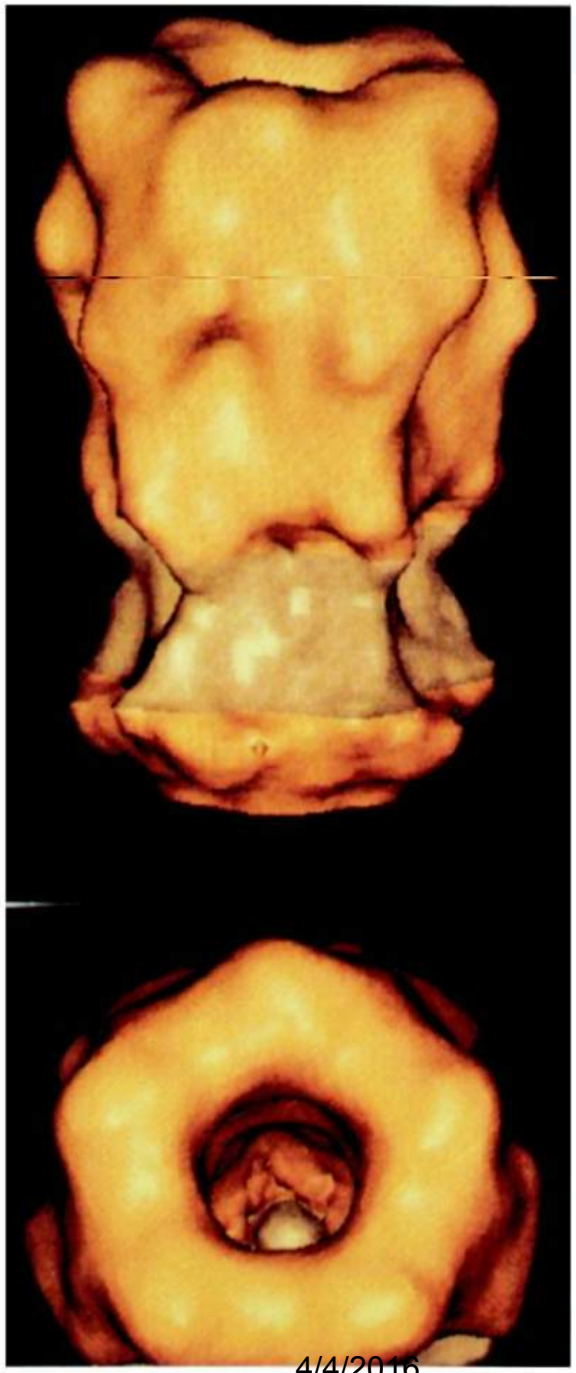
Acetylcholine esterase



Acetylcholine nicotinic receptor "Ionotropic receptor"




A
pore
Synaptic entrance
neurotransmitter binding pocket
gate
cytoplasmic entrance
B
D
synapse
M2
C
N

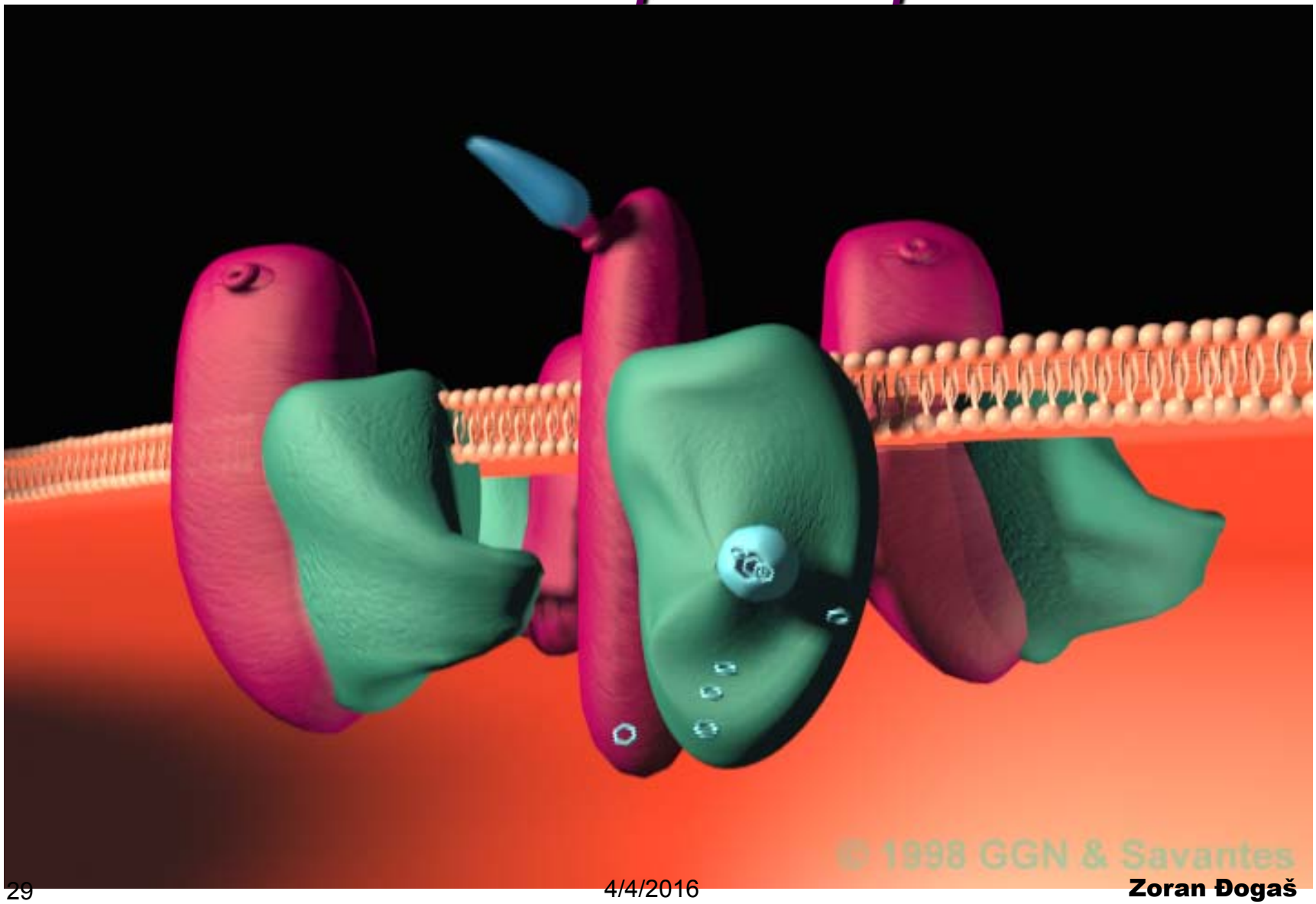


ACh receptor (nAChR)

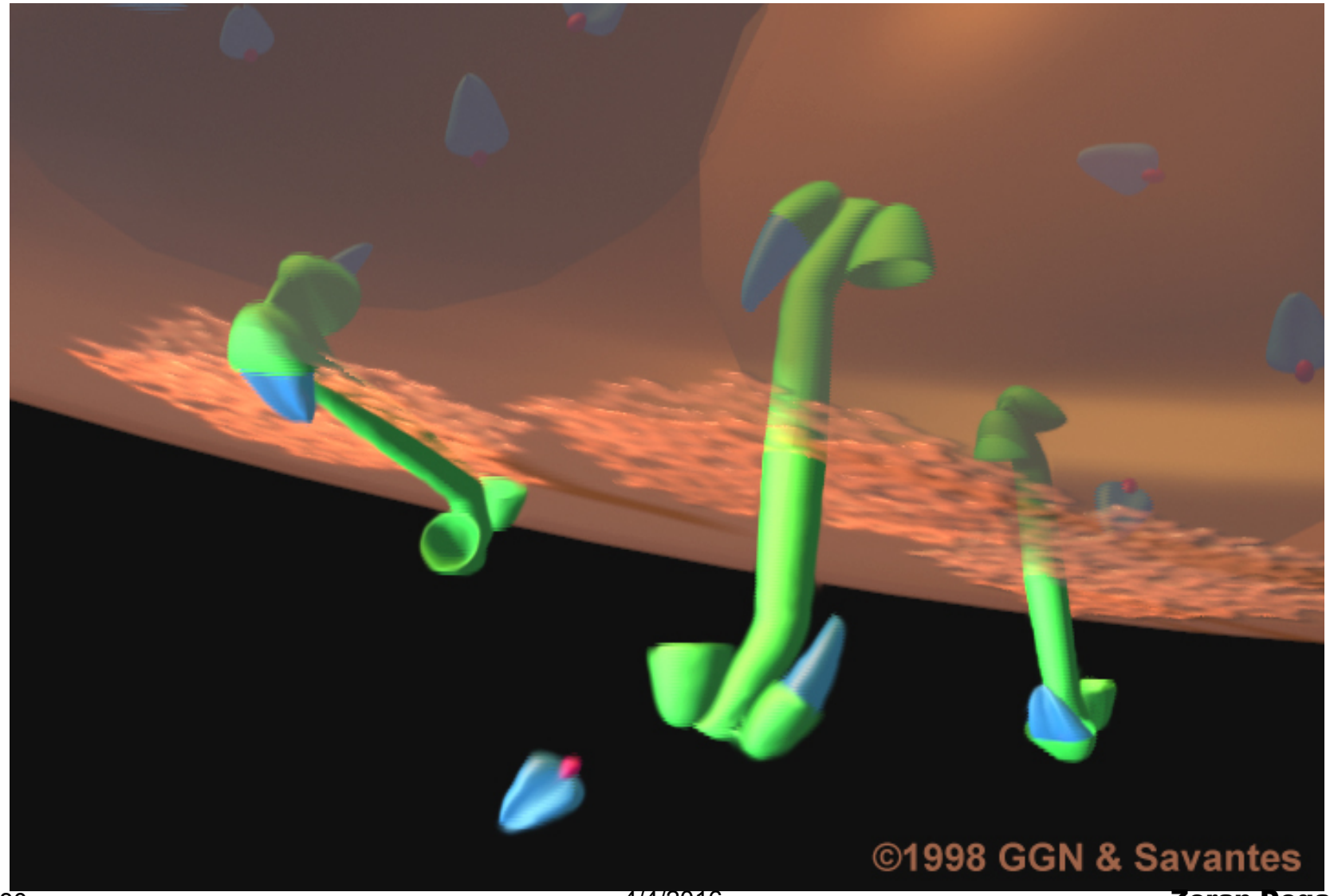
computer rendering imaged by cryo-electron microscopy

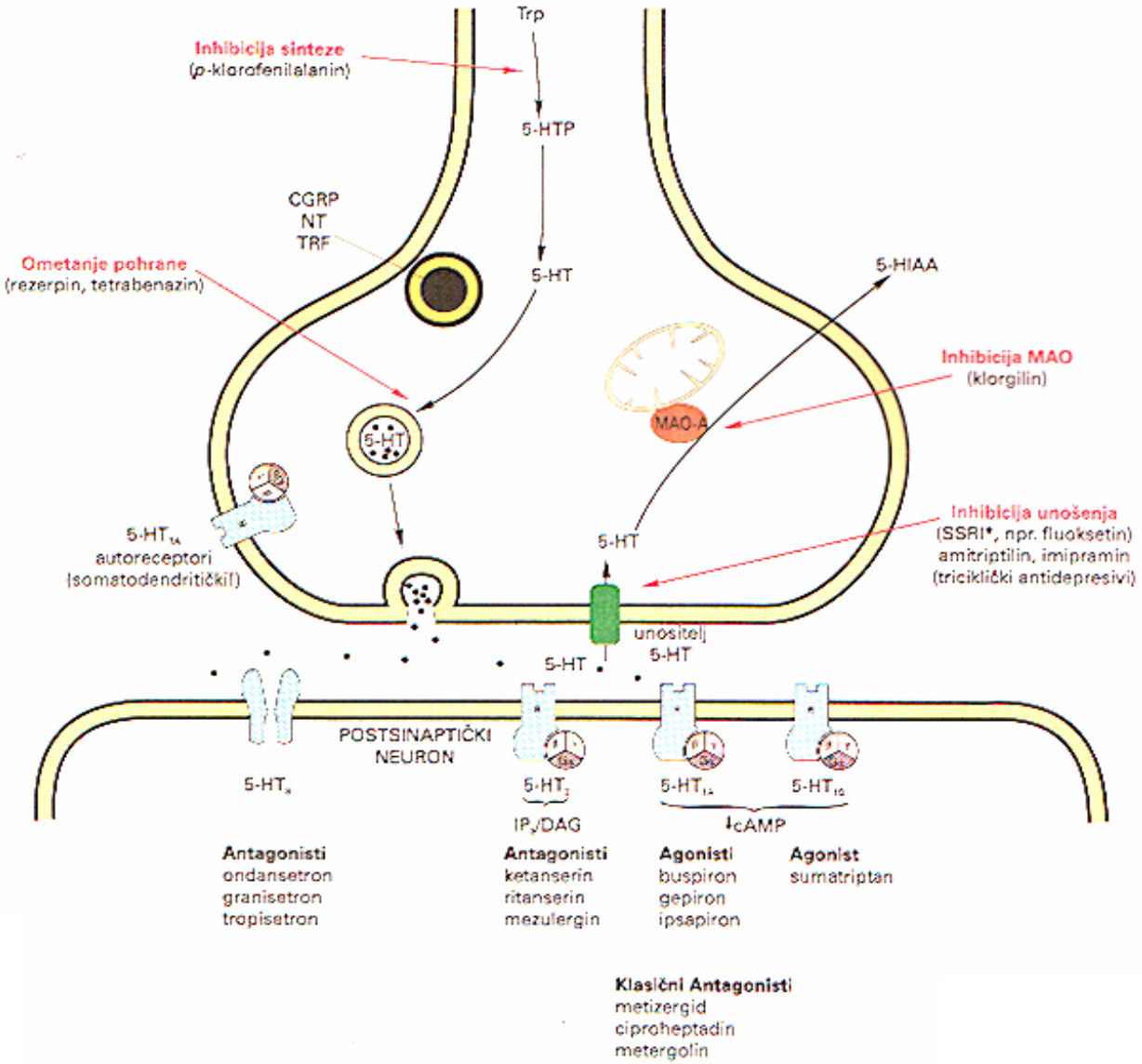
Dopamine receptor

"Metabotropic receptor"



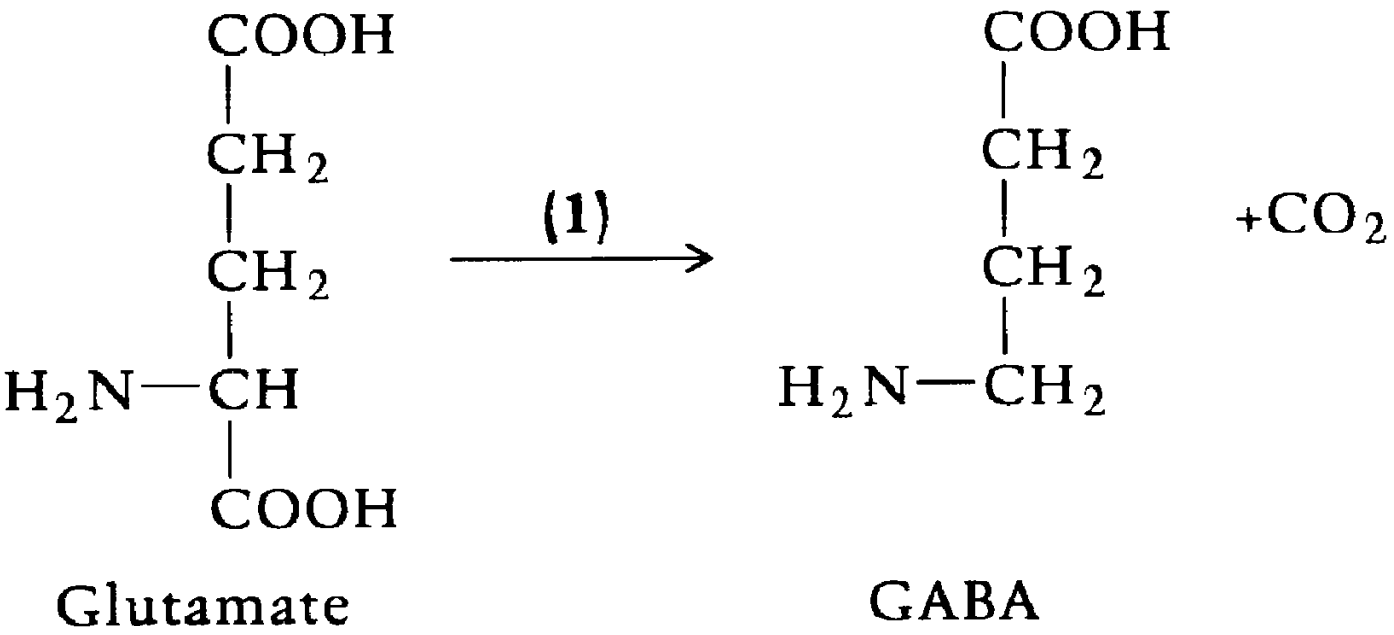
Re-uptake mechanism



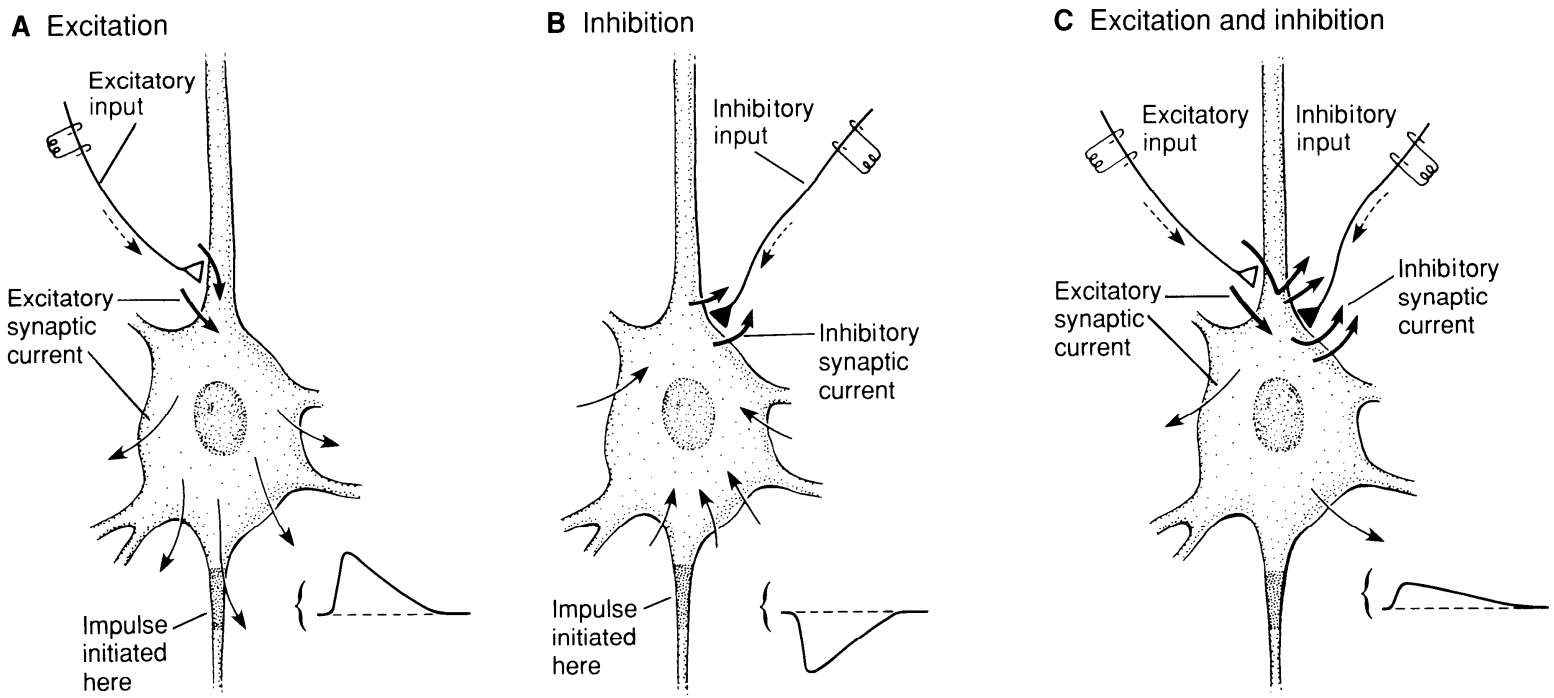


Slika 11-12. Sažetak o serotoninu. Za pojedinosti vidi tekst.

Chemical reaction
GABA from glutamate



IPSPs and EPSPs generation



Classical neurotransmitters

GABA, glutamate

glycine, serotonin, dopamine, acetilcholine,

(nor)adrenaline, histamine

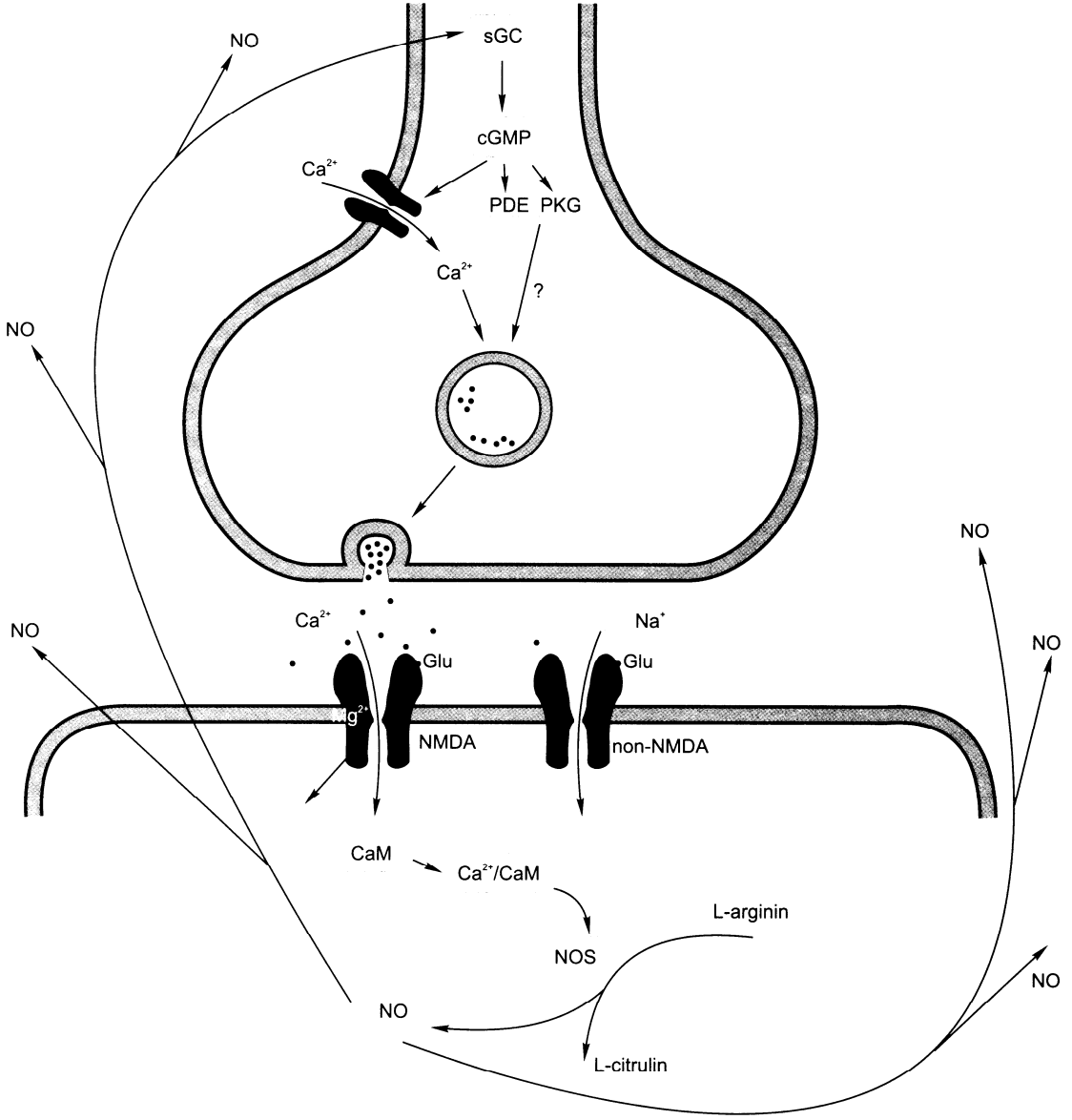
IDENTIFICATION METHODS

Evidences for classical neurotransmitters:

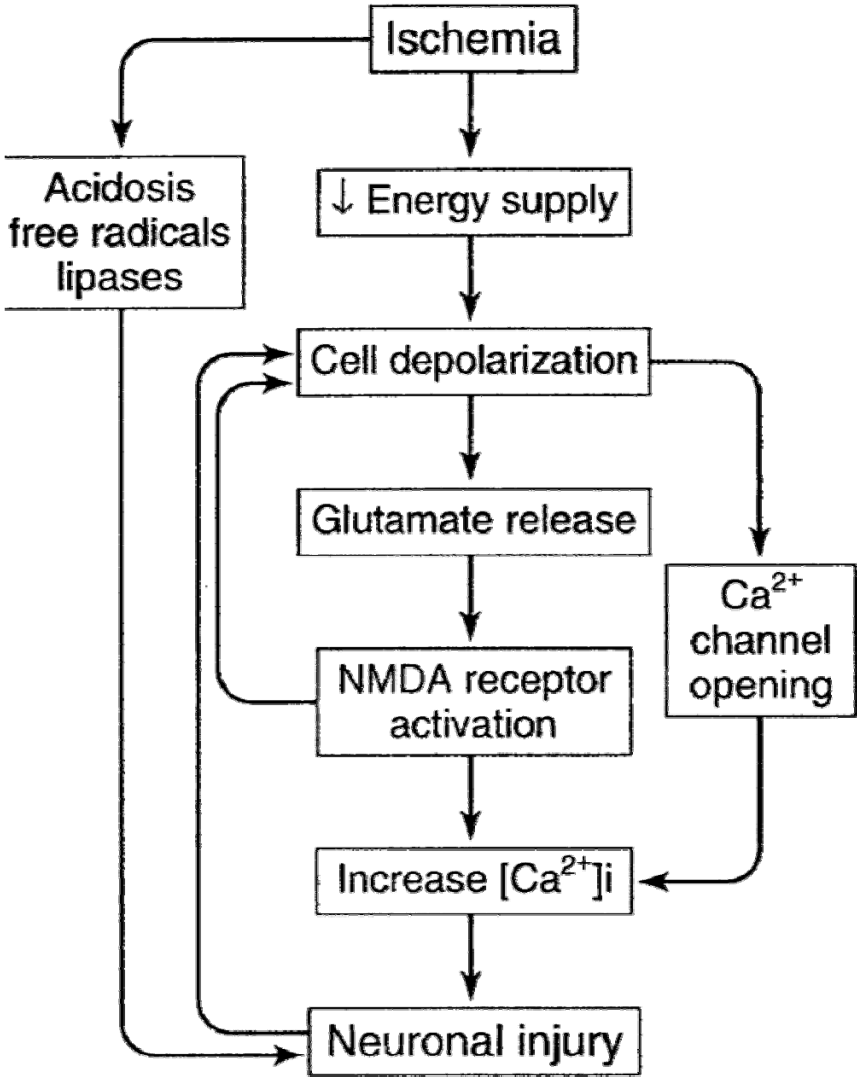
- Anatomical – presence
- Biochemical – enzimes
- Physiological – exocitosis
- Pharmacological – agonists/antagonists

NO

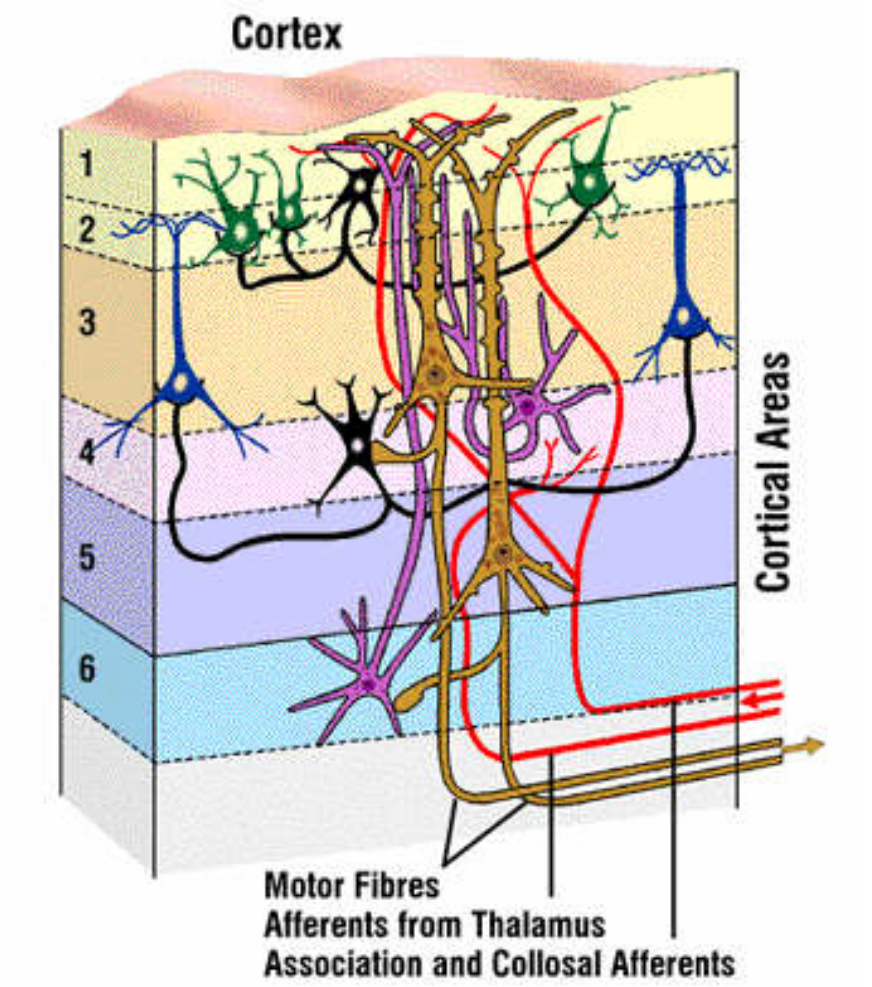
Mechanism of Learning and Memory



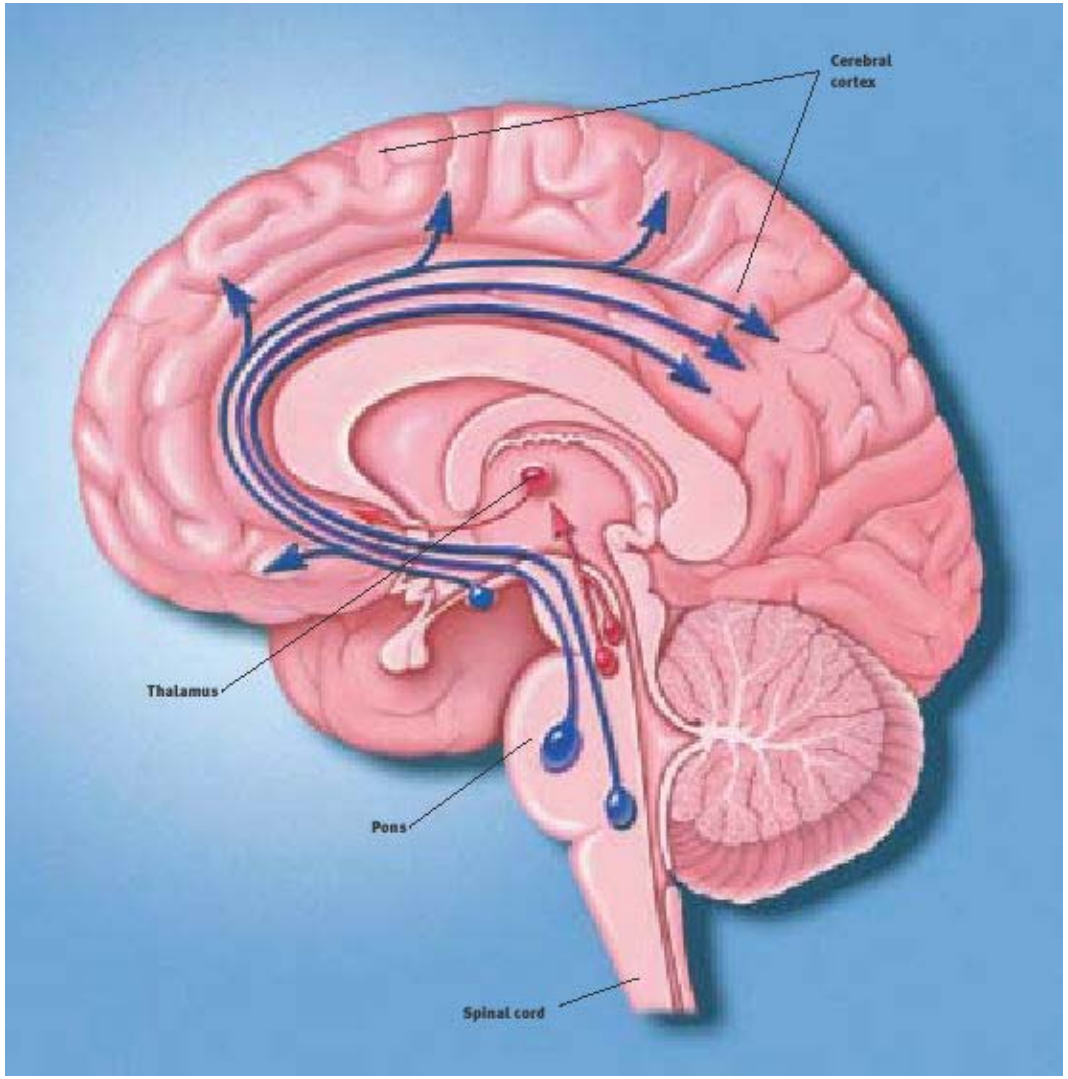
Ischemic stroke



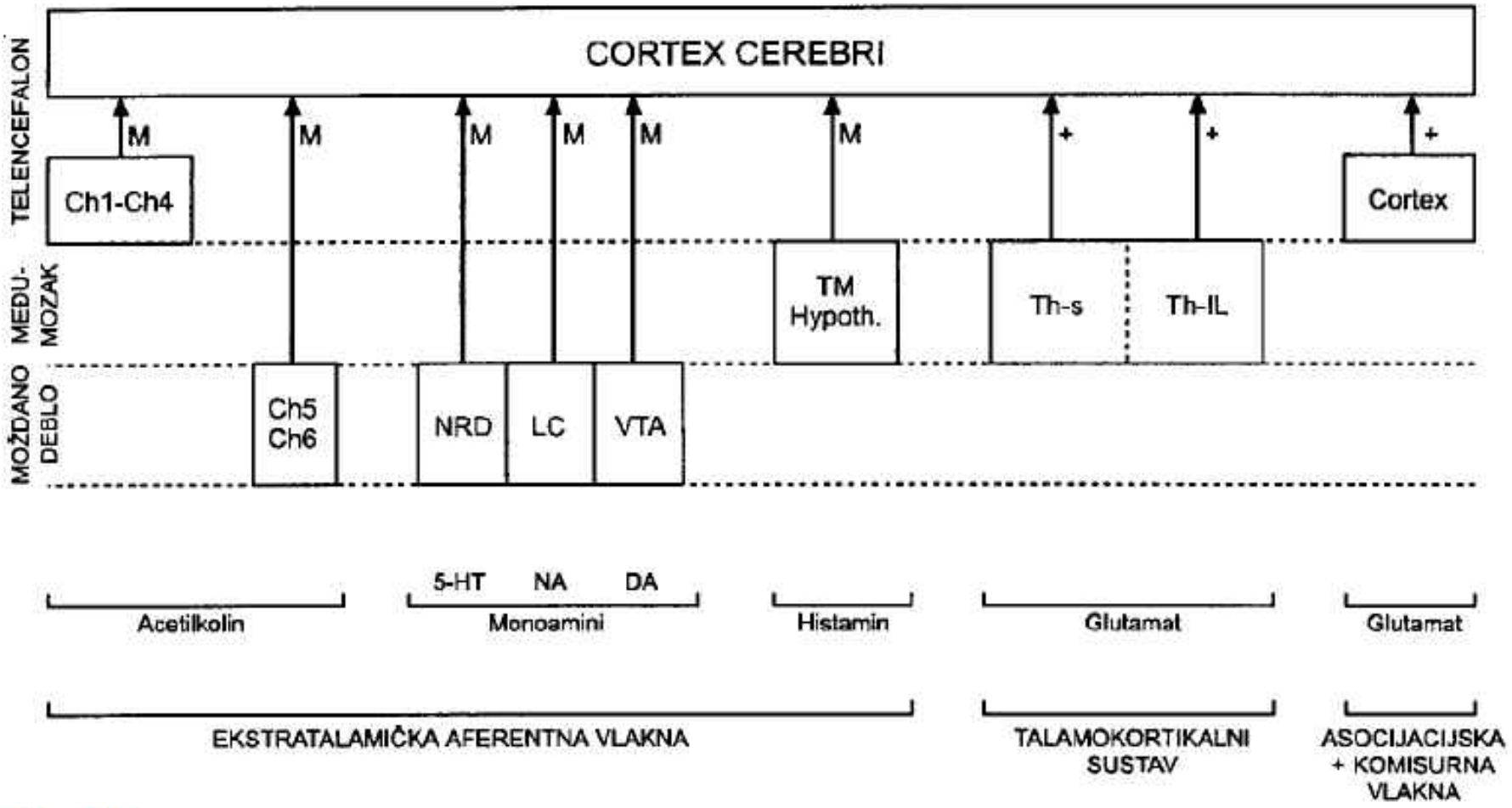
Cortical layers



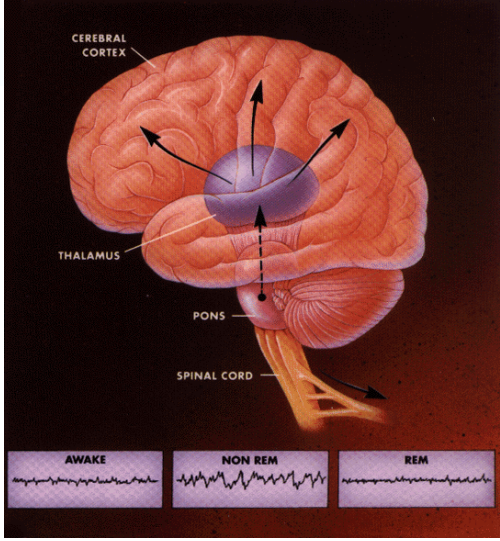
Pathways to Cortex

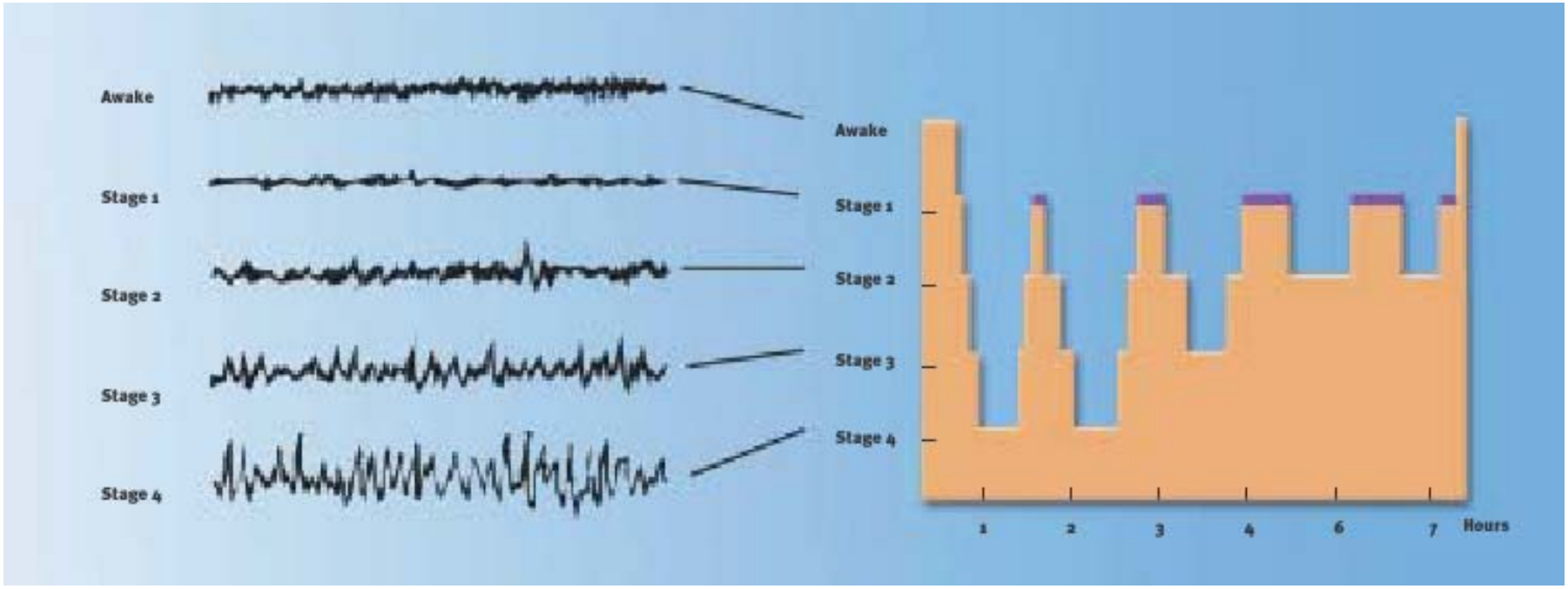


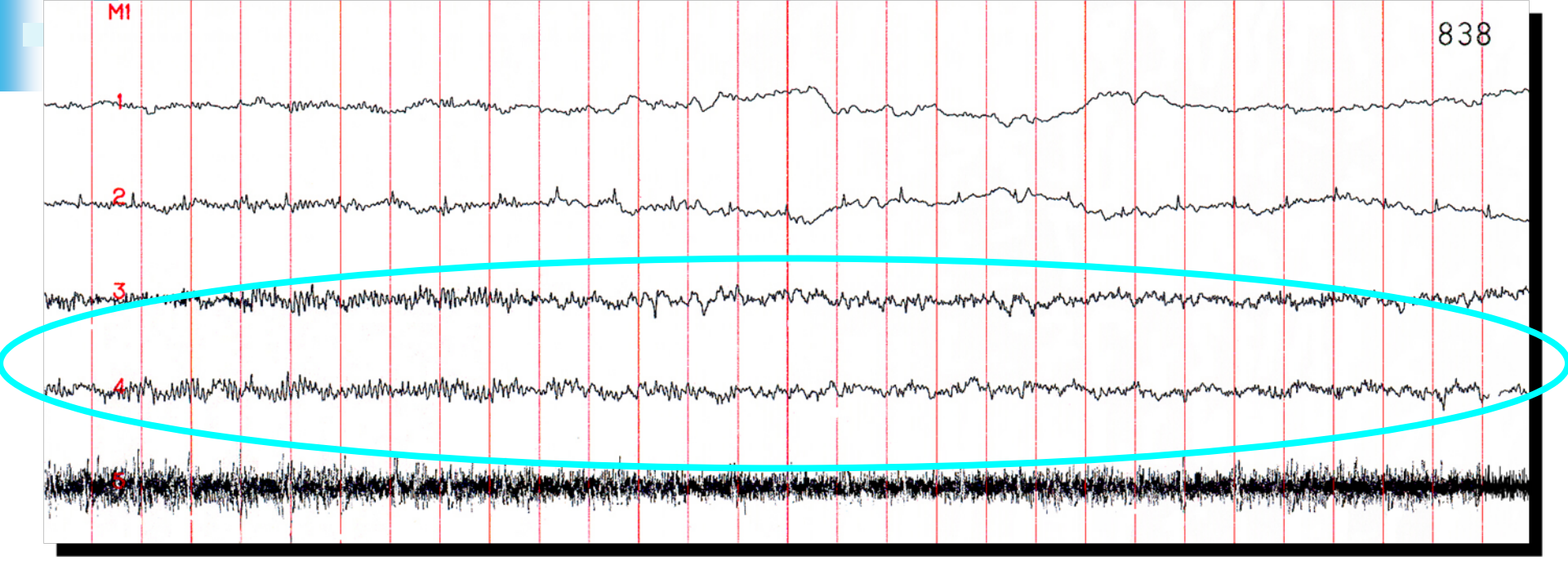
Projections to Cortex

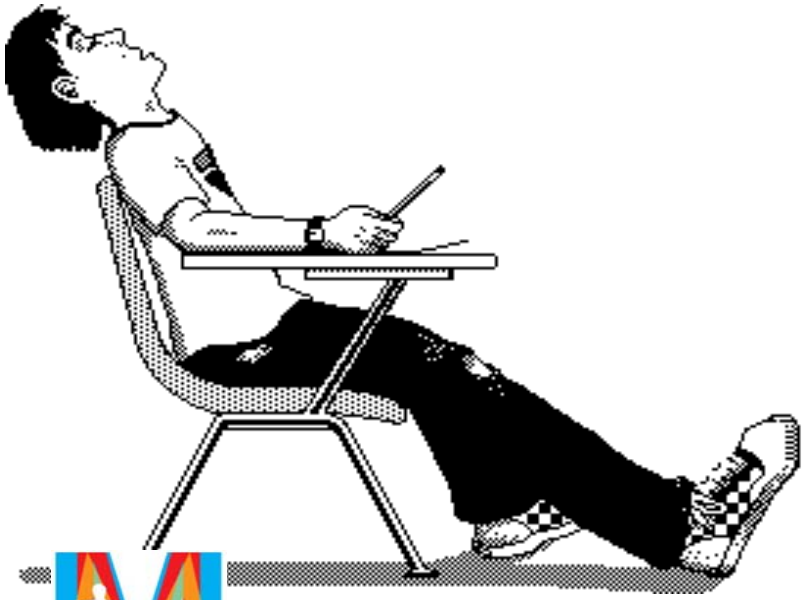


Sleep Stages



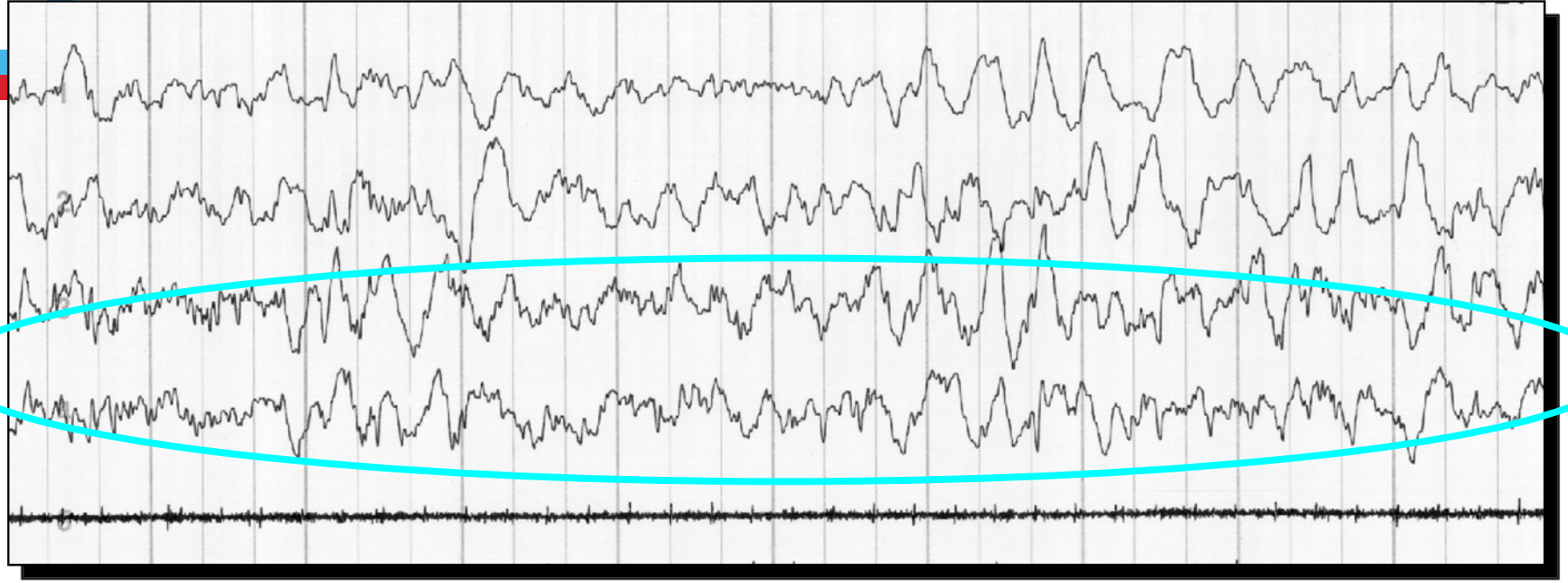




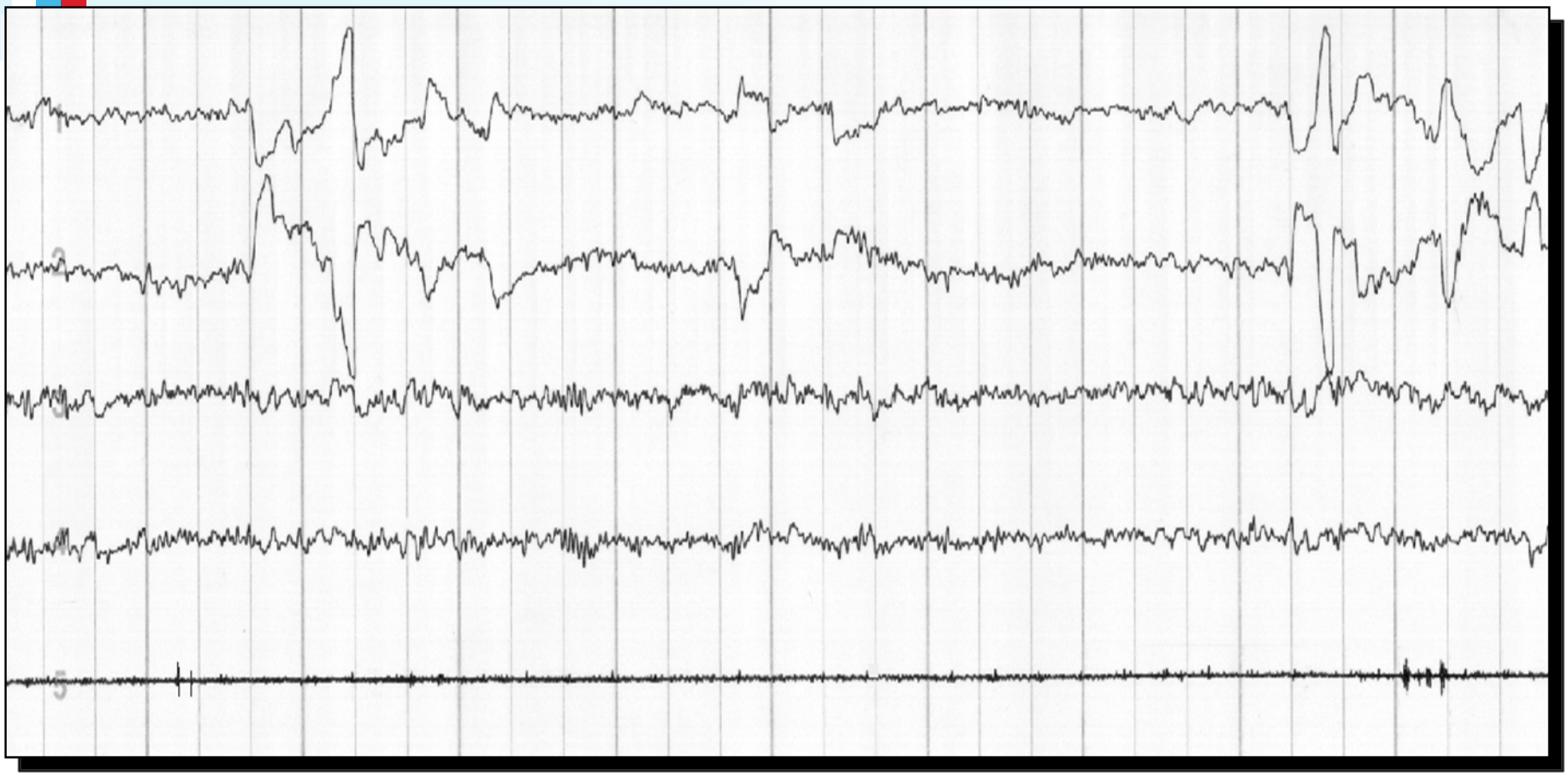


Stage 1
Church sleep
Car driving sleep

Boring lecture sleep



Slow Wave (deep) sleep

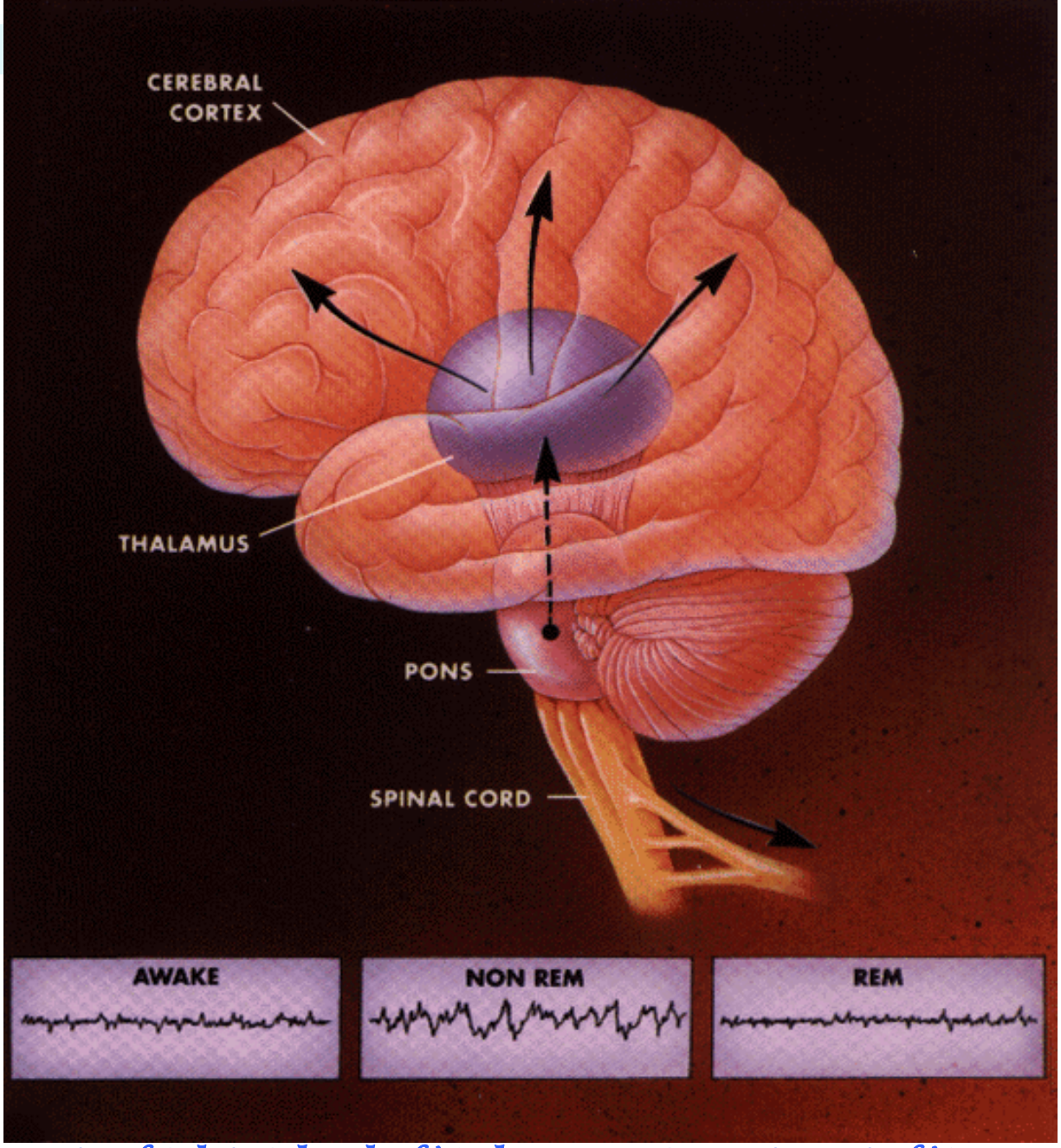


REM sleep:

•REM; Rapid Eye Movements,

•Fast Brain Activity,

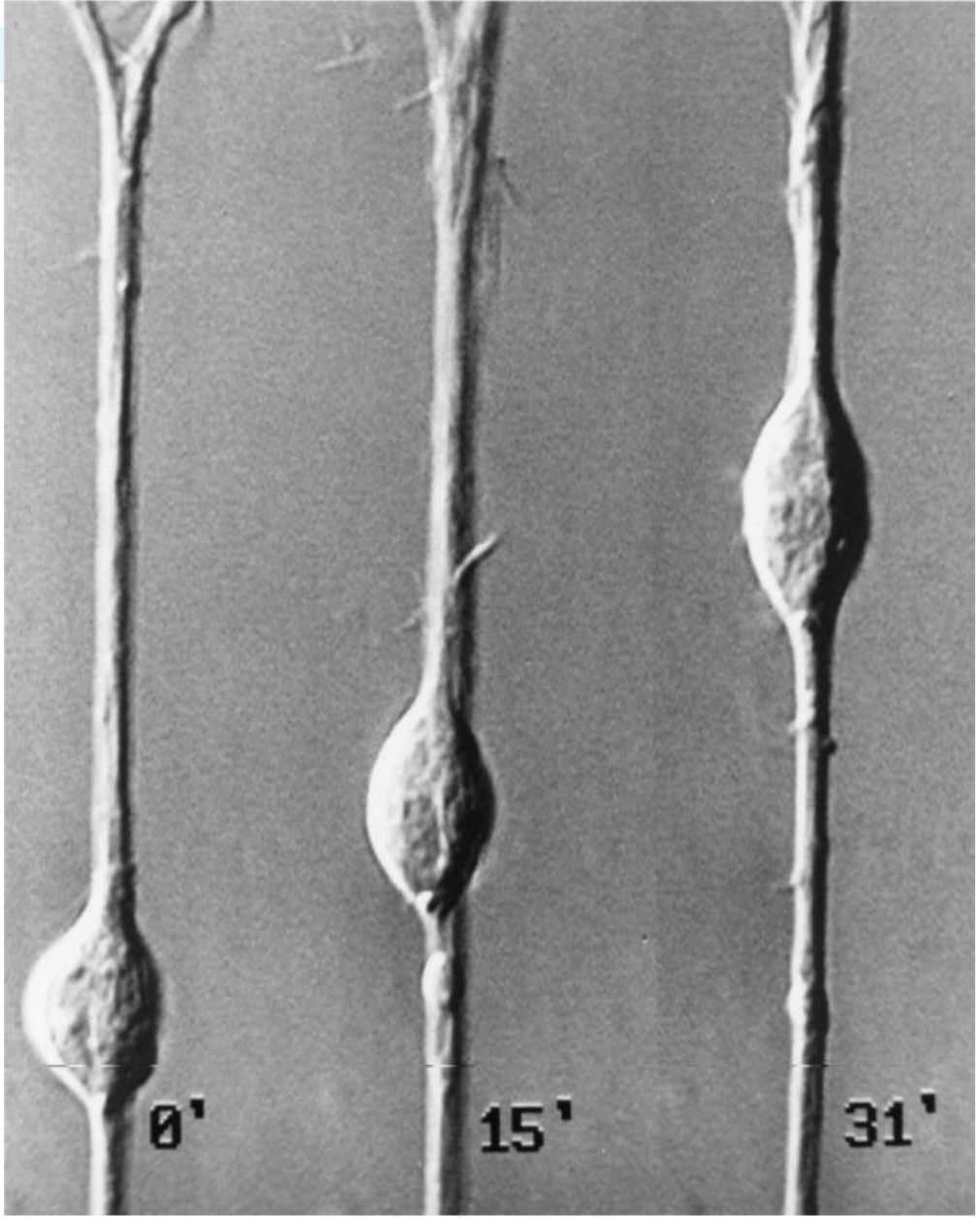
•Atonia of skeletal muscles


CEREBRAL CORTEX
THALAMUS
PONS
SPINAL CORD
AWAKE
NON REM
REM

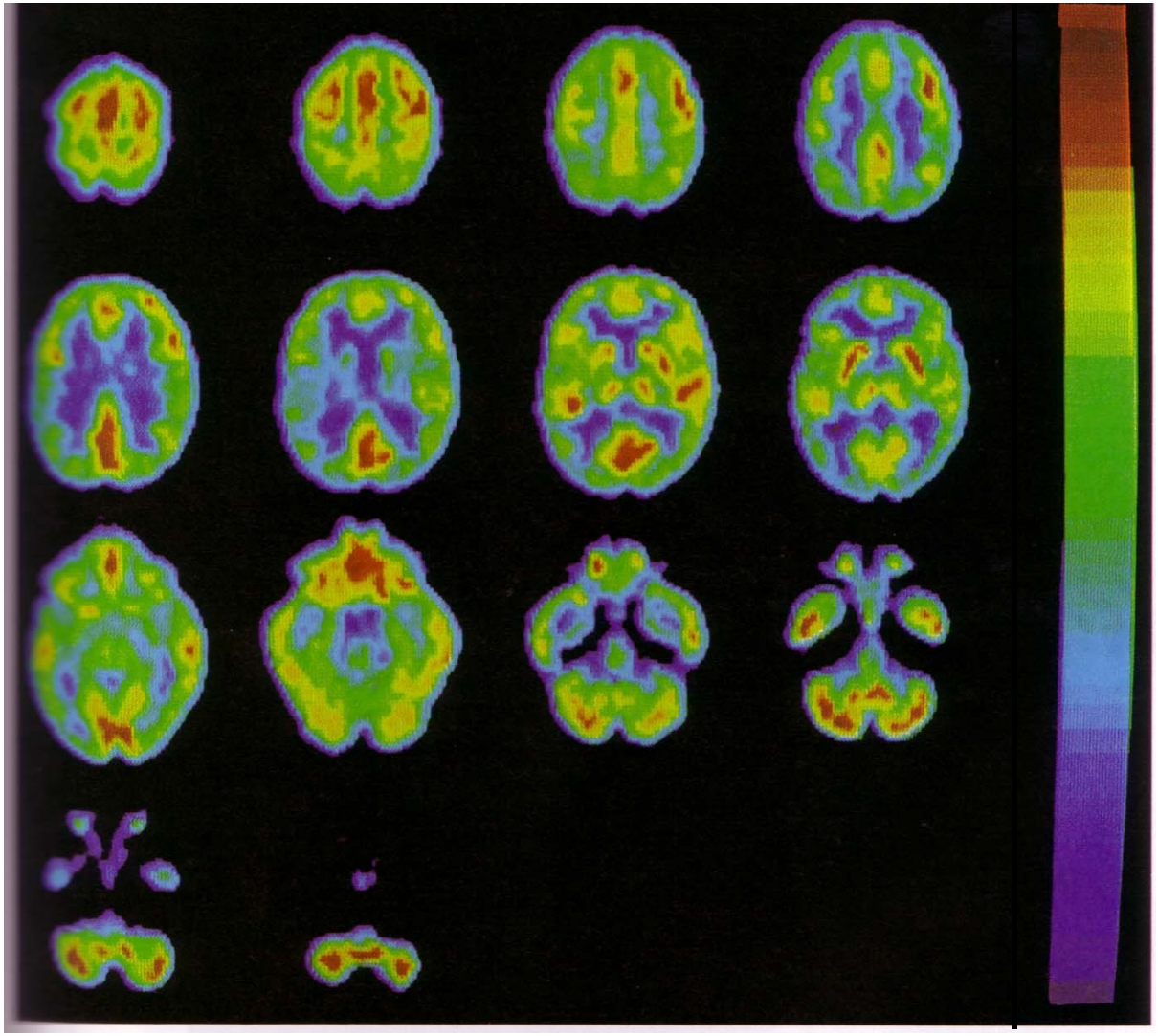
THE BRAIN

FROM THE BLACK BOX

TO THE BRAIN AWARENESS WEEK



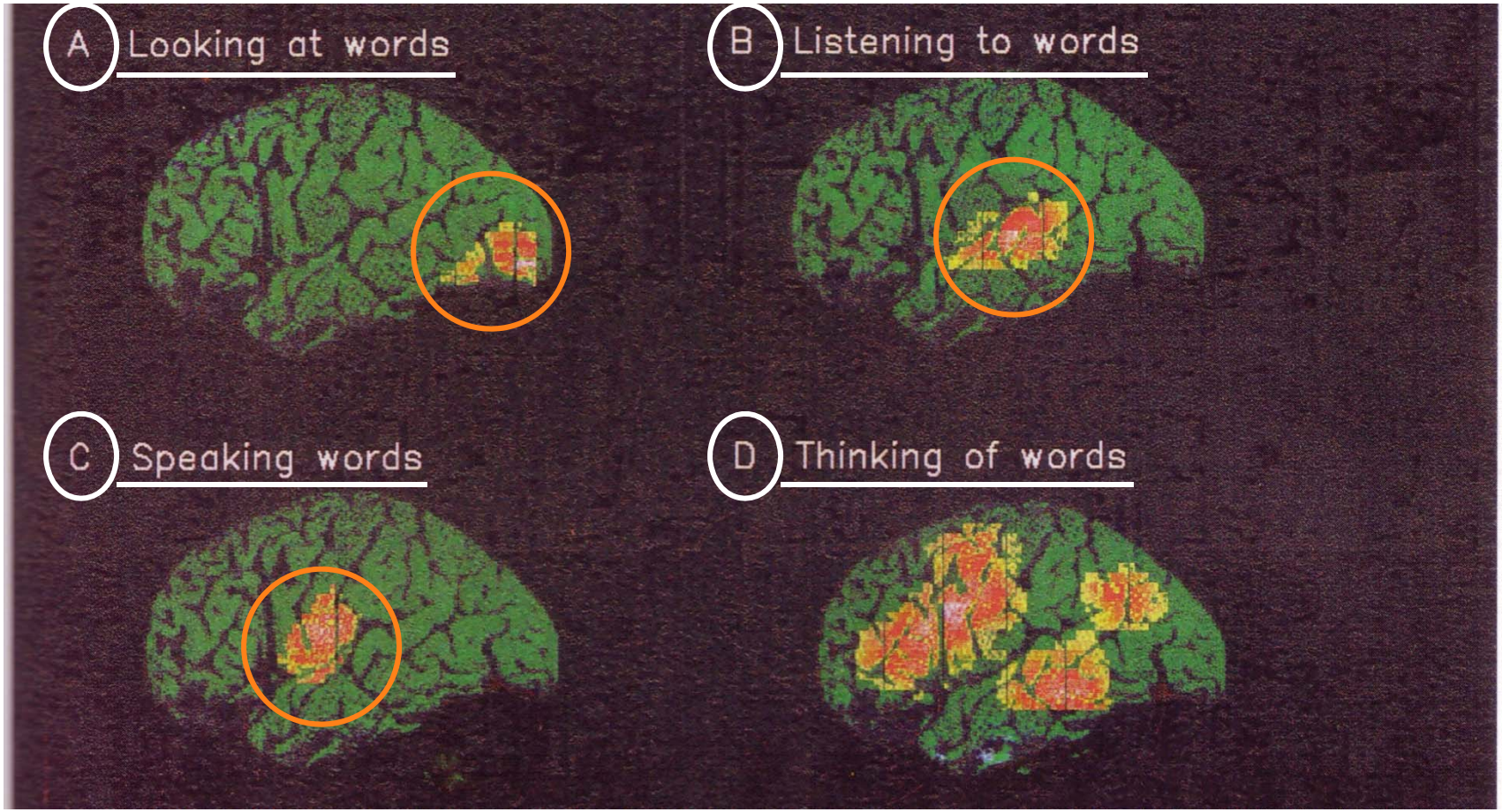
Brain activity- PET/CT



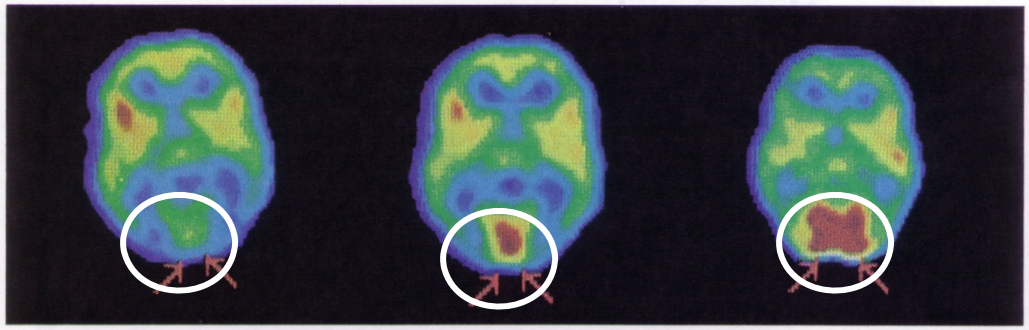
Highly active

inactive

Cortical activity

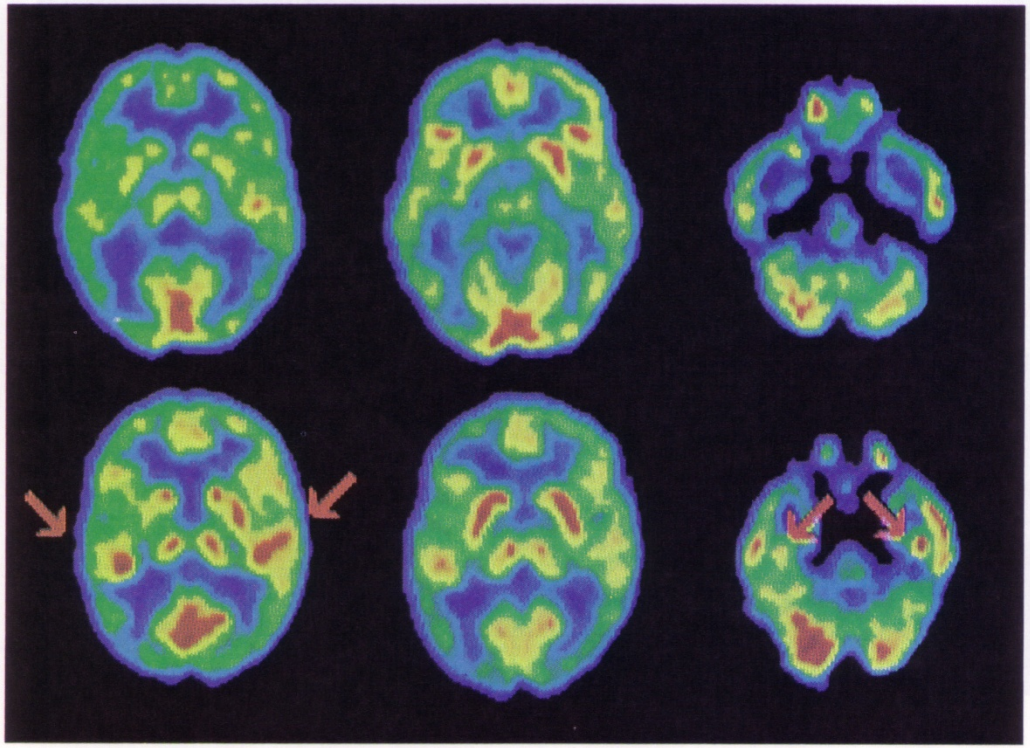


Visual stimulation



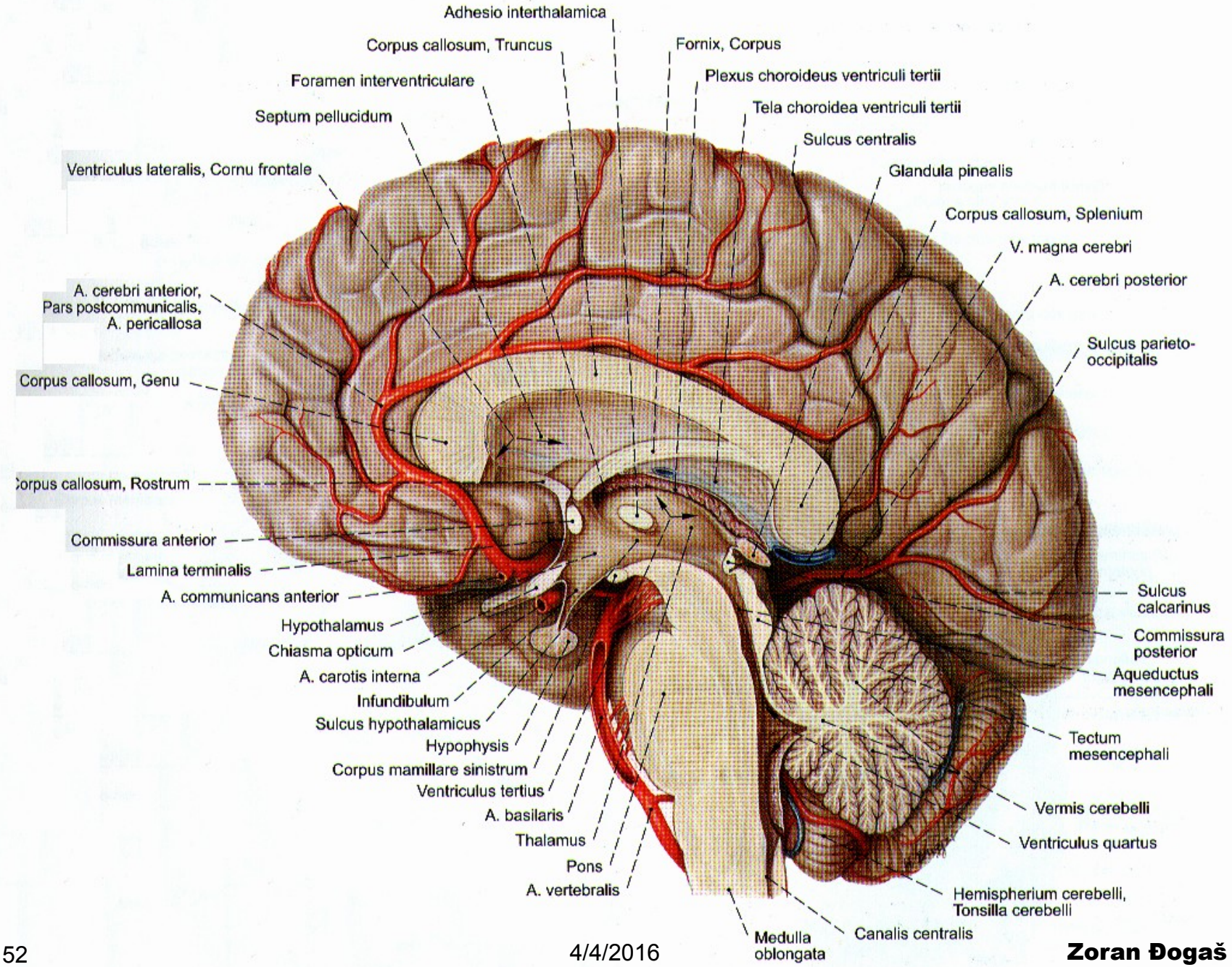
Eyes closed | White light | Complex scene

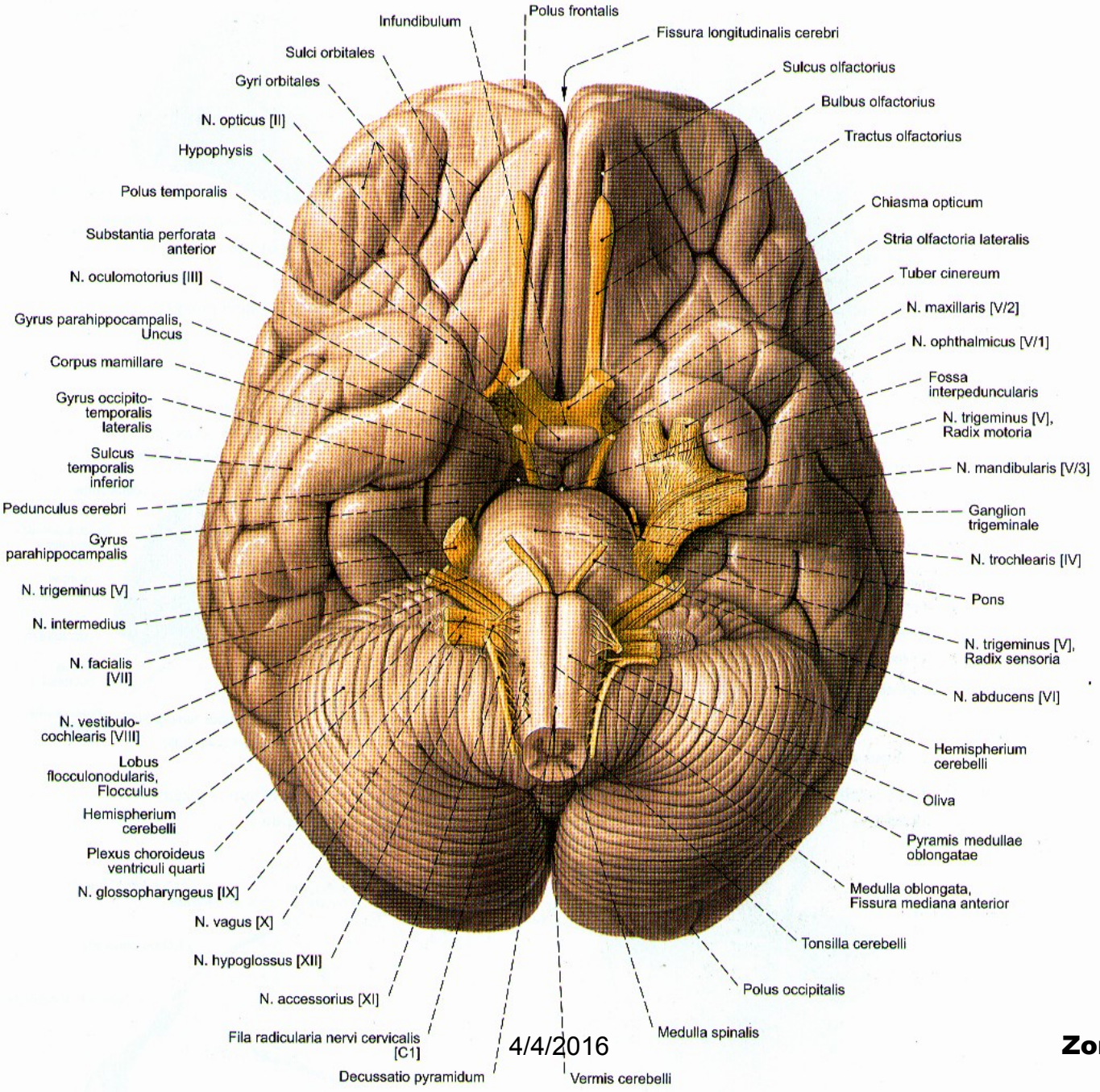
Auditory stimulation

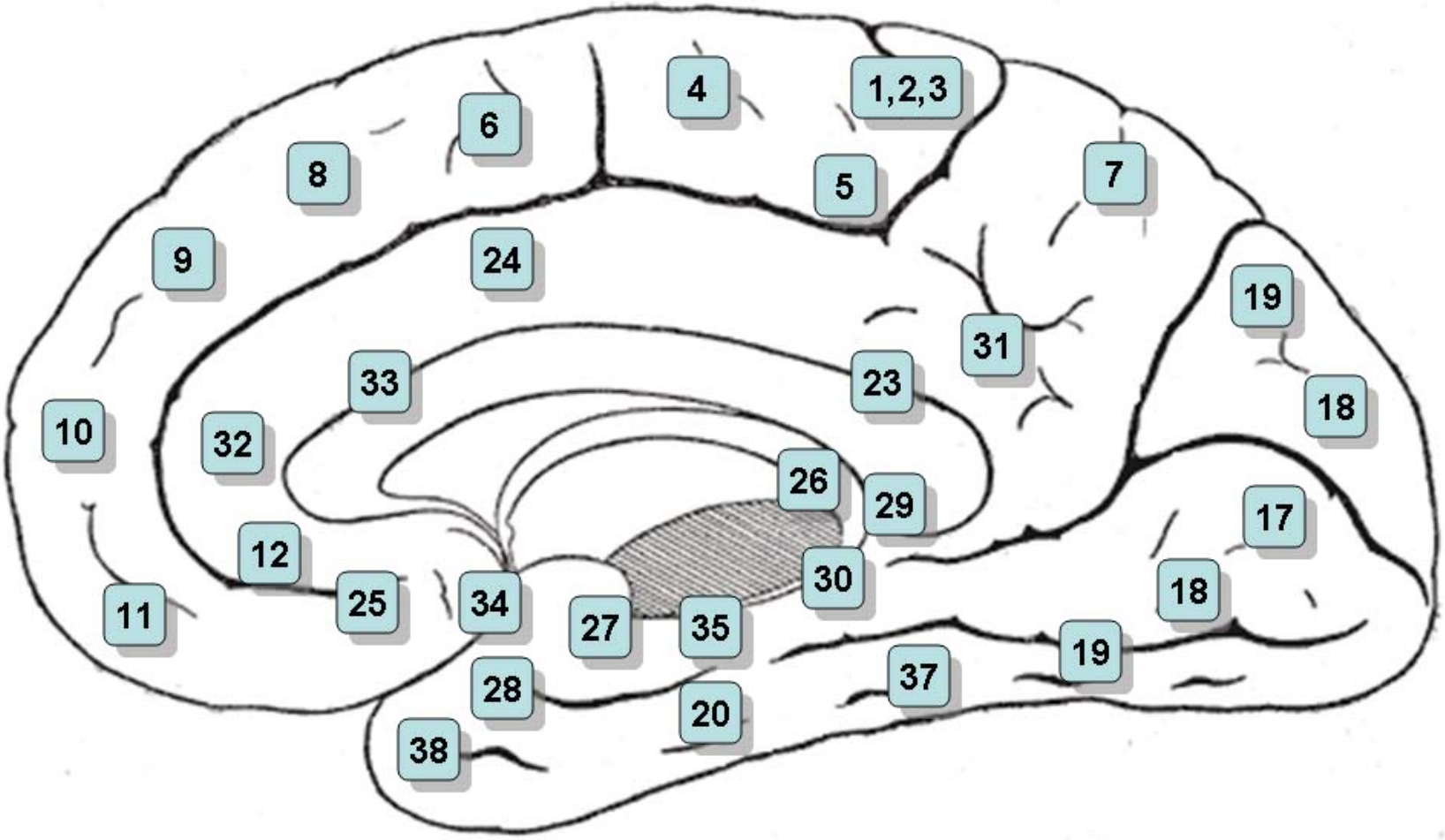


Control

Stimulation


Adhesio interthalamica
Corpus callosum, Truncus
Fornix, Corpus
Foramen interventriculare
Plexus choroideus ventriculi tertii
Septum pellucidum
Tela choroidea ventriculi tertii
Sulcus centralis
Ventriculus lateralis, Cornu frontale
Glandula pinealis
Corpus callosum, Splenium
V. magna cerebri
A. cerebri anterior,
Pars postcommunicalis,
A. pericallosa
A. cerebri posterior
Sulcus parieto-
occipitalis
Corpus callosum, Genu
Corpus callosum, Rostrum
Commissura anterior
Lamina terminalis
A. communicans anterior
Sulcus
calcarinus
Hypothalamus
Commissura
posterior
Chiasma opticum
A. carotis interna
Aqueductus
mesencephali
Infundibulum
Sulcus hypothalamicus
Tectum
mesencephali
Hypophysis
Corpus mamillare sinistrum
Vermis cerebelli
Ventriculus tertius
A. basilaris
Ventriculus quartus
Thalamus
Pons
A. vertebralis
Hemispherium cerebelli,
Tonsilla cerebelli
Medulla
oblongata
Canalis centralis


Infundibulum
Polus frontalis
Fissura longitudinalis cerebri
Sulci orbitales
Sulcus olfactorius
Gyri orbitales
Bulbus olfactorius
N. opticus [II]
Tractus olfactorius
Hypophysis
Chiasma opticum
Polus temporalis
Stria olfactoria lateralis
Substantia perforata anterior
Tuber cinereum
N. oculomotorius [III]
N. maxillaris [V/2]
Gyrus parahippocampalis, Uncus
N. ophthalmicus [V/1]
Corpus mamillare
Fossa interpeduncularis
Gyrus occipito-temporalis lateralis
N. trigeminus [V], Radix motoria
Sulcus temporalis inferior
N. mandibularis [V/3]
Pedunculus cerebri
Ganglion trigeminale
Gyrus parahippocampalis
N. trochlearis [IV]
N. trigeminus [V]
Pons
N. intermedius
N. trigeminus [V], Radix sensoria
N. facialis [VII]
N. abducens [VI]
N. vestibulo-cochlearis [VIII]
Hemispherium cerebelli
Lobus flocculonodularis, Flocculus
Oliva
Hemispherium cerebelli
Pyramis medullae oblongatae
Plexus choroideus ventriculi quarti
Medulla oblongata, Fissura mediana anterior
N. glossopharyngeus [IX]
N. vagus [X]
Tonsilla cerebelli
N. hypoglossus [XII]
Polus occipitalis
N. accessorius [XI]
Medulla spinalis
Fila radicularia nervi cervicalis [C1]
Decussatio pyramidum
Vermis cerebelli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1,2,3
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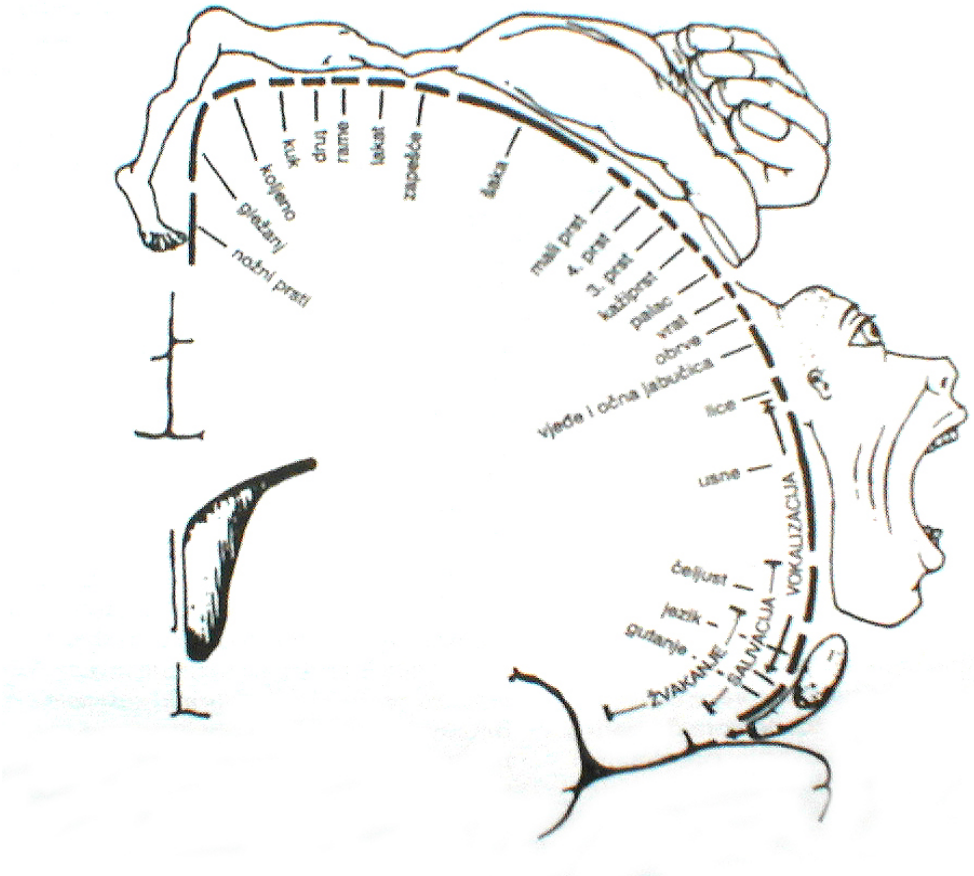
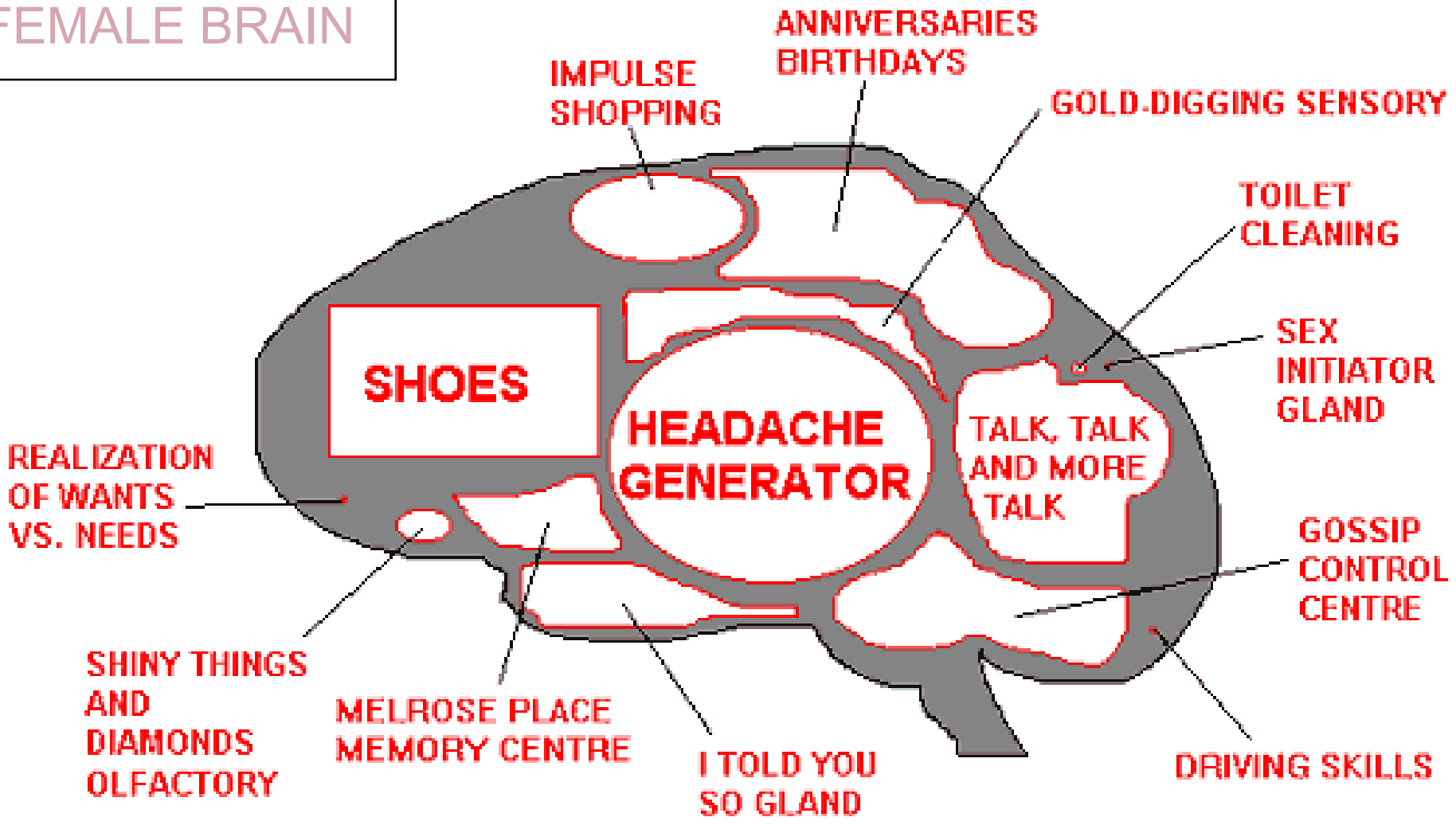
HOMUNCULUS

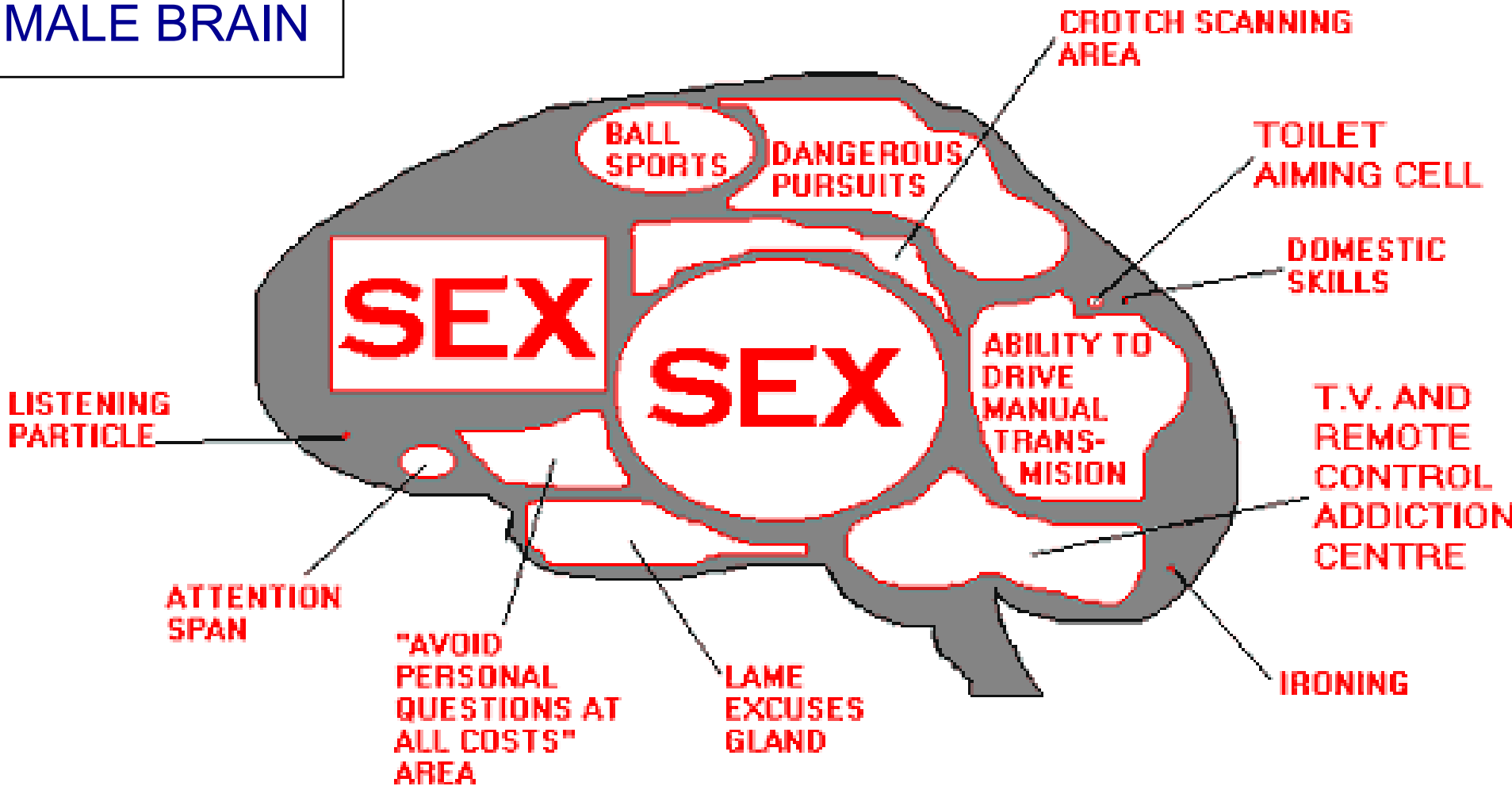

kuk
koljeno
gležanj
nožni prsti
trup
ruka
lakat
zapešće
šaka
mali prst
4. prst
3. prst
kažiprst
palac
vrat
obrve
vjeđe i očna jabučica
lice
usne
VOKALIZACIJA
čeljust
jezik
gutanje
ŽVAKANJE
SALIVACIJA

FEMALE BRAIN



FOOTNOTE: The "Put Oil into the Car" and "Be Quiet During the Game" glands are active only when the "SHINY THINGS AND DIAMONDS" OLFactory has been satisfied or when there is a shoe sale.

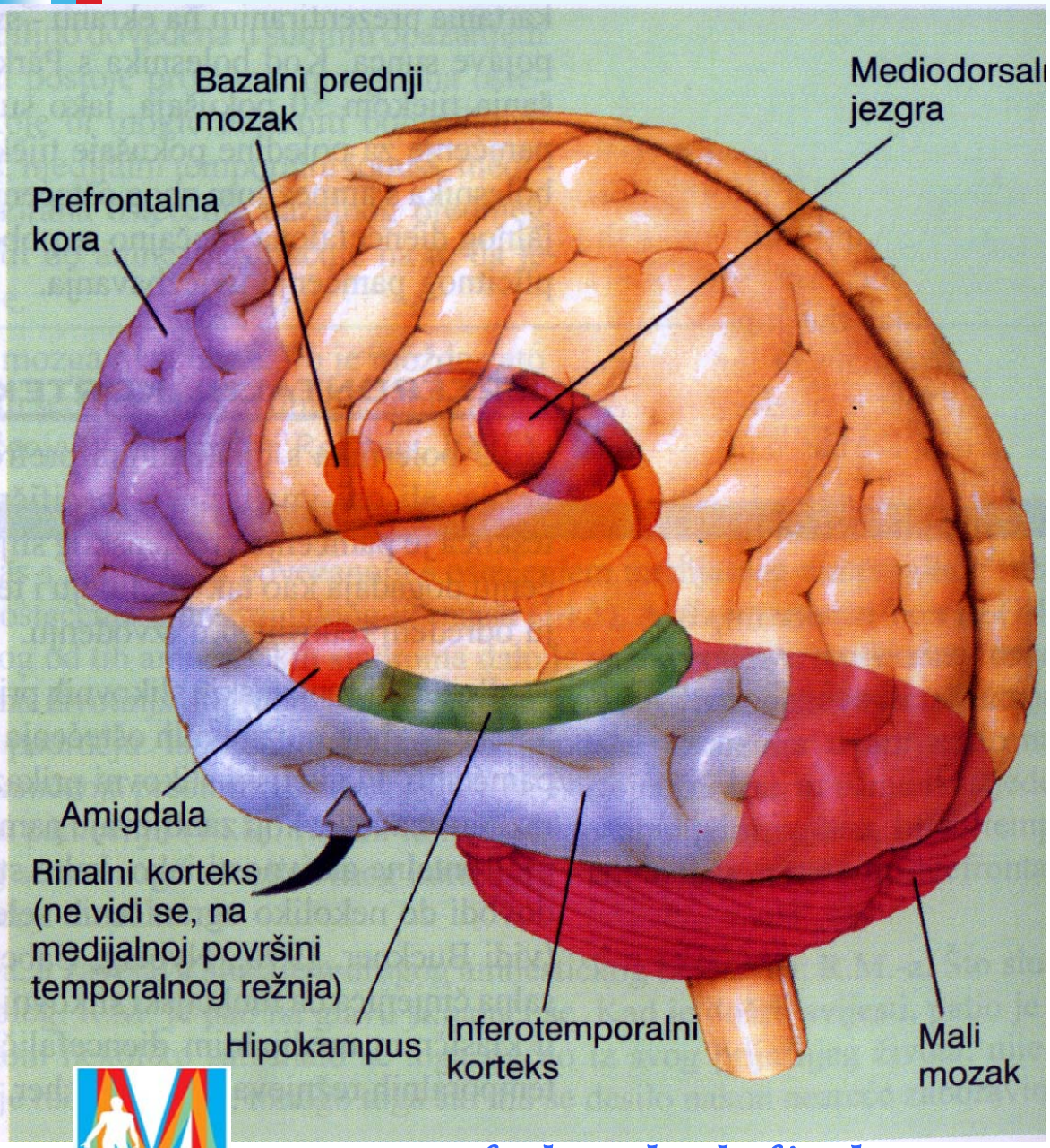
MALE BRAIN



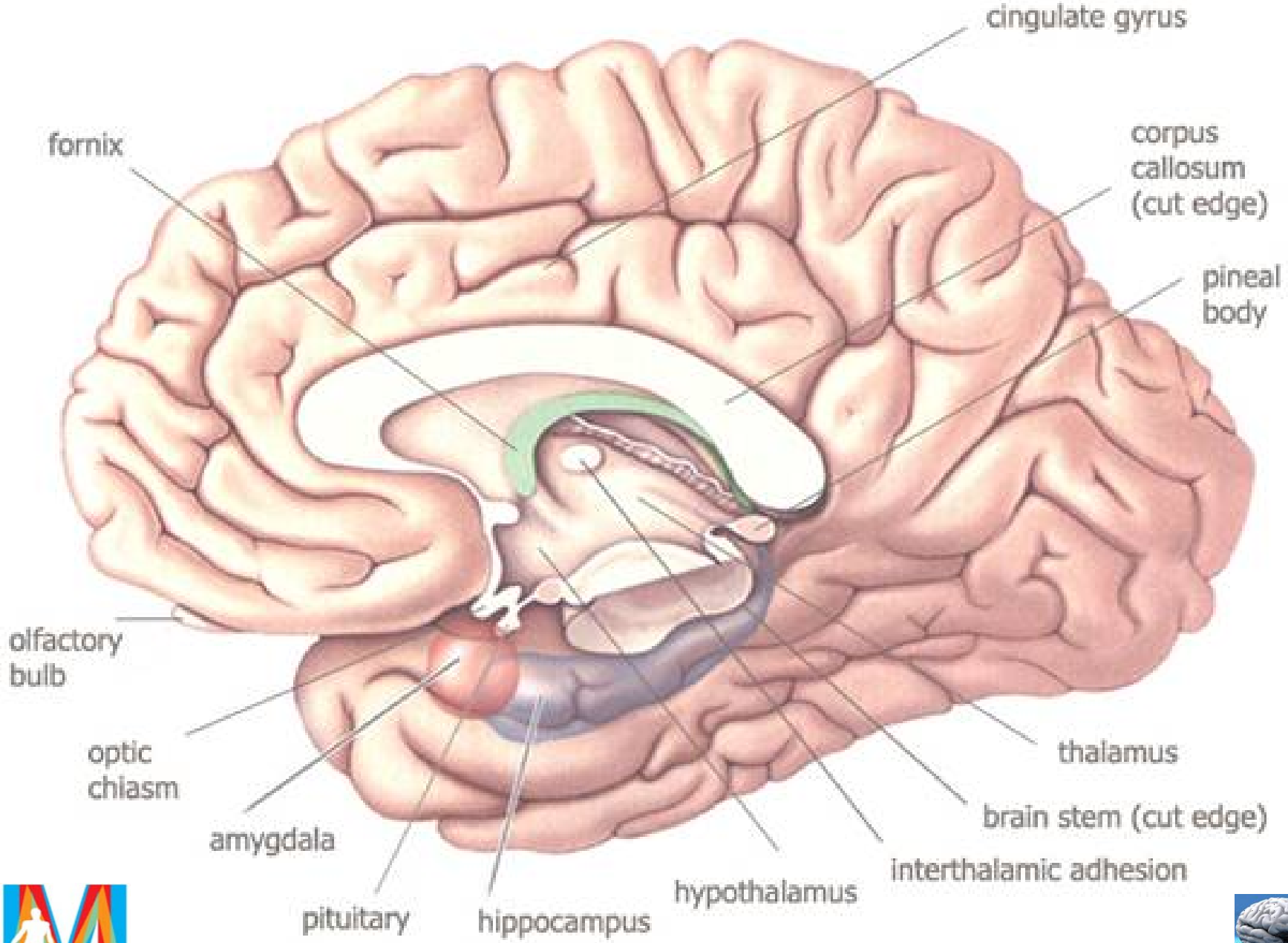
FOOTNOTE: the "Listening to children cry in the middle of the night" gland is not shown due to it's small and underdeveloped nature. Best viewed under a microscope.

BRAIN PLASTICITY

Learning & Memory



- Rinalni korteks – novo dugoročno eksplicitno pamćenje
- Hipokampus – dugoročno pamćenje položaja u prostoru
- Amigdala – pamćenje čuvstvenih značenja određenih iskustava
- Sekundarni senzorni korteks i asocijativni korteks – neuralni krugovi za pohranu dugoročnog pamćenja
- Implicitno pamćenje – senzomotorički zadaci – mali mozak i strijatni sustav (dopaminergičke strukture – kaudatus i putamen)
- Prefrontalni korteks – vremenski slijed događaja

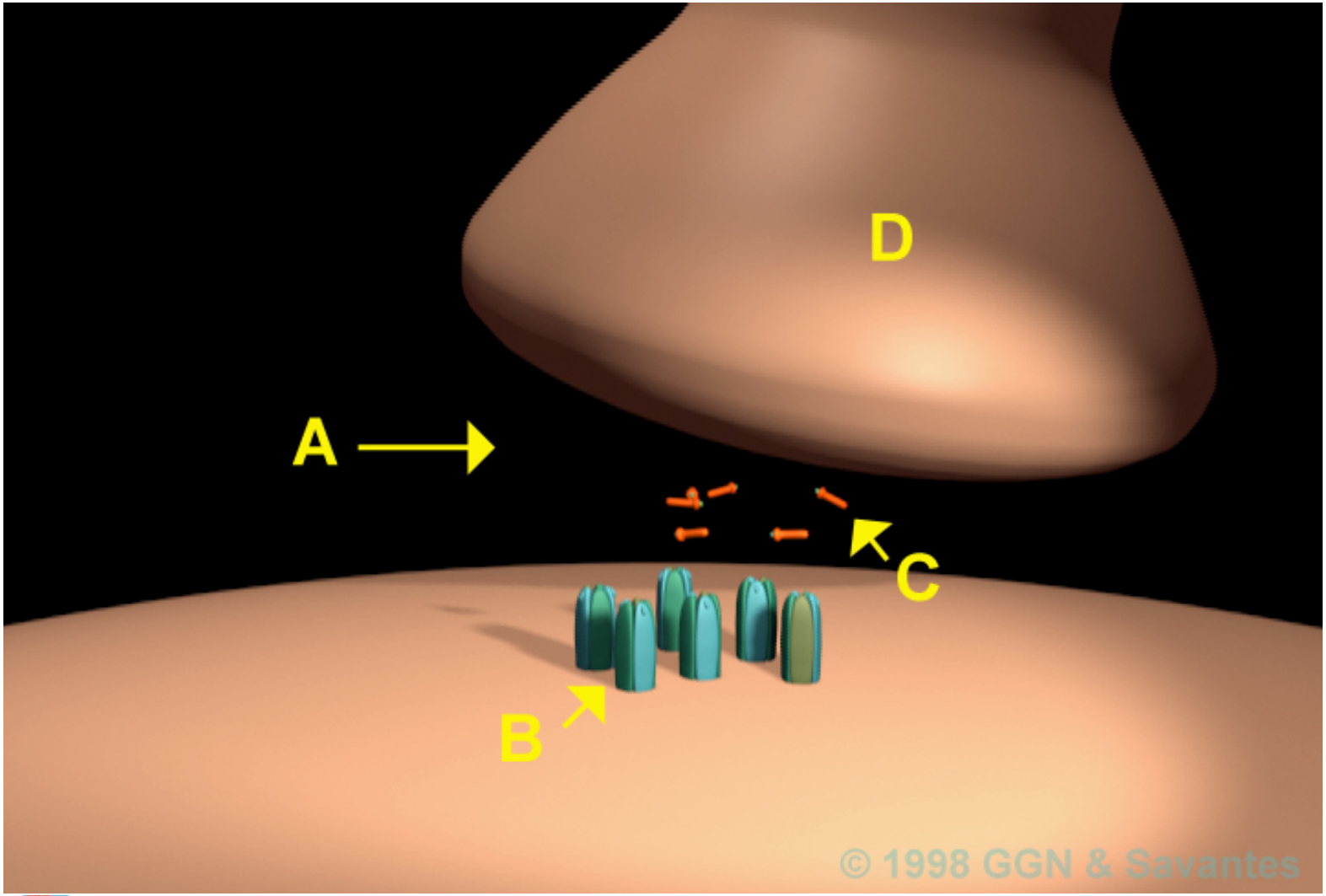

cingulate gyrus
fornix
corpus callosum (cut edge)
pineal body
olfactory bulb
optic chiasm
amygdala
thalamus
brain stem (cut edge)
interthalamic adhesion
hypothalamus
pituitary
hippocampus

An example of the brain plasticity

LTP-Long Term Potentiation in the hyppocampus

Cellular mechanism of Learning and Memory

Synaptic connection

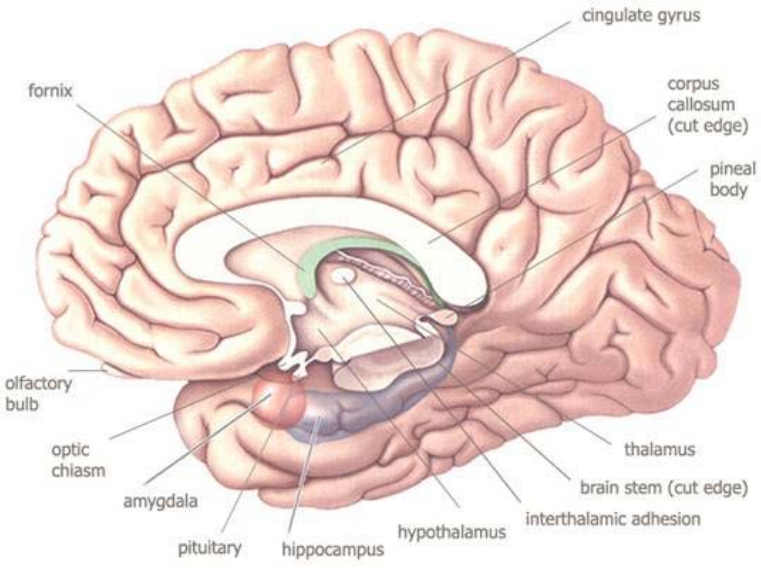


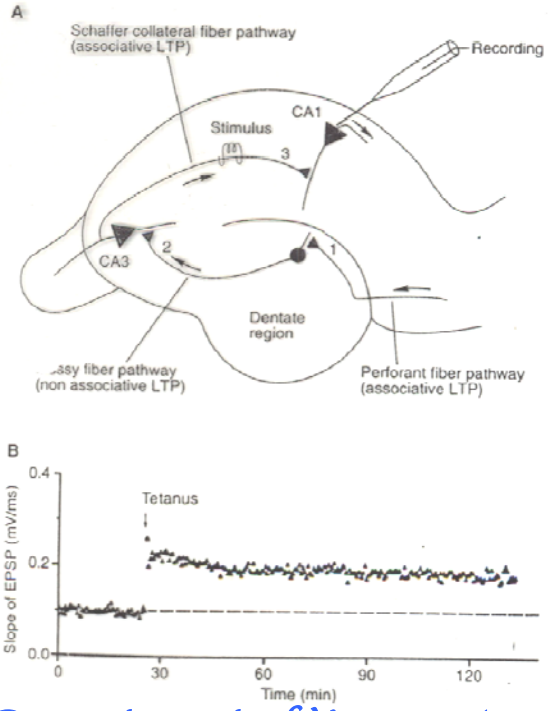
NO

+ GLUTAMATE
(NMDA)

Learning and memory
an example of brain plasticity

LTP-Long Term Potentiation
Cellular mechanism of L&M





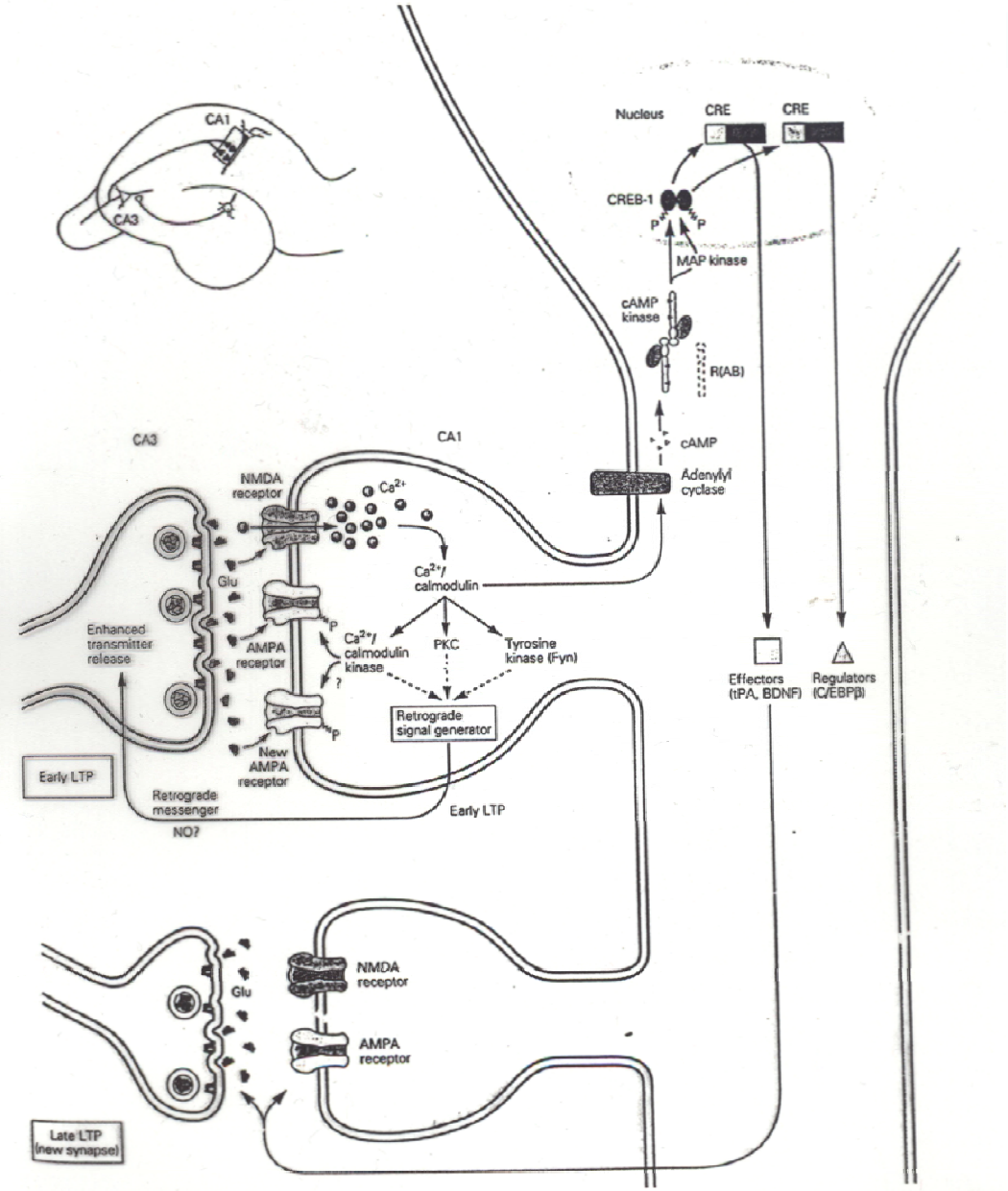


Figure 63-13 A model for the early and late phase of LTP. A single train of action potentials leads to early LTP by activating

protein. CREB in turn activates targets that are thought to lead to structural changes. Mutations in mice that block PKA or

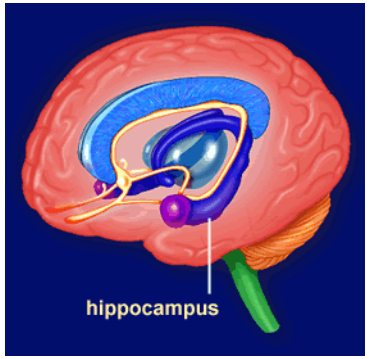
translocation to the nucleus, where it phosphorylates the CREB

dominant negative PKA; tPA = tissue plasminogen activator.

Teaching methodology
Teachers' task

Let us be a stimulus for LTP generation

This way we will create new synapses in the brains of our students



Education purpose?

Is it achieved or...?

The purpose of an education is to fill vessels and to light fires...

Today, we fill the vessels so full, they overflow and put out the fire...

THANK YOU FOR YOUR ATTENTION!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