

# TELENCEPHALON

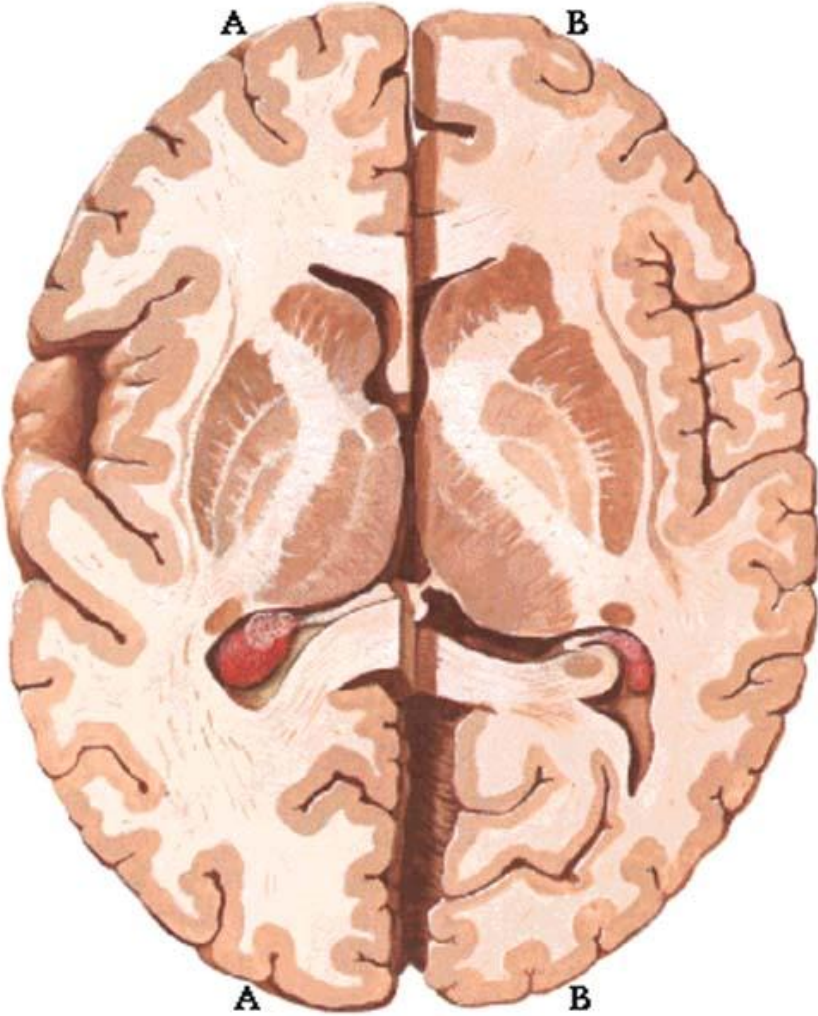
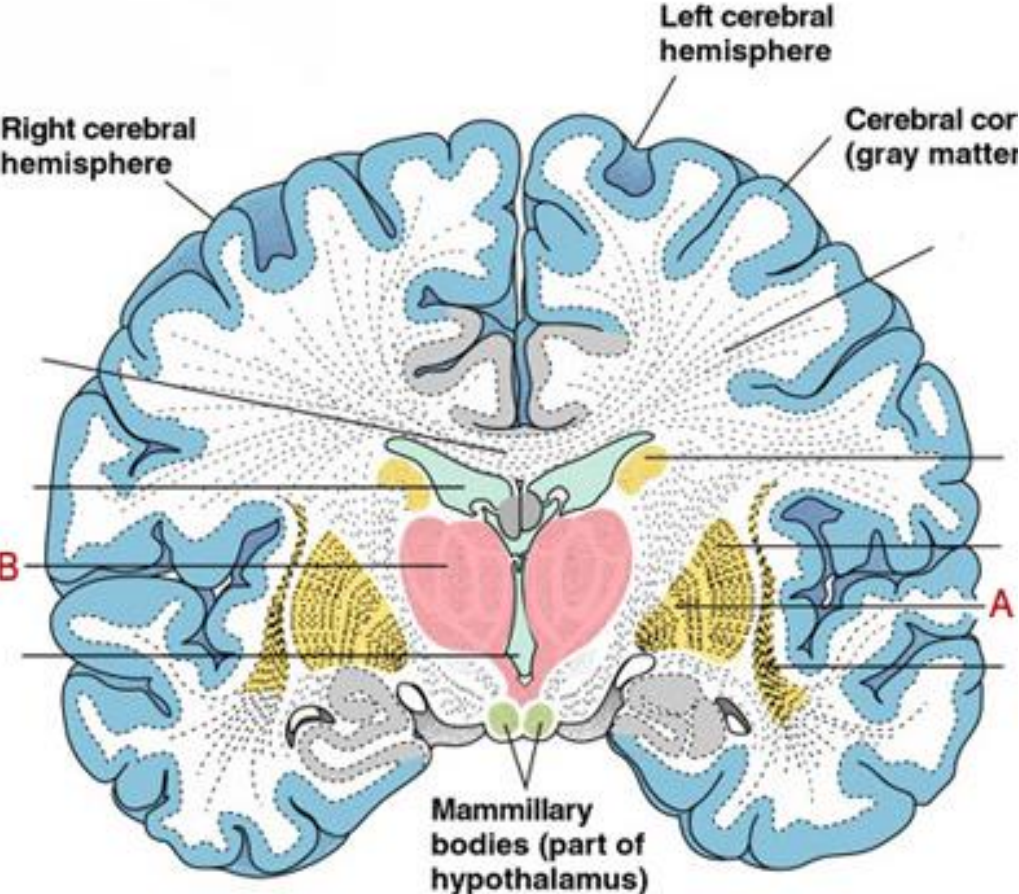
Basal ganglia

# Telencephalon = Cerebrum

- **Middle part (= telencephalon medium)**
  - Rostral part of IIIrd ventricle
  - Prior to foramen interventriculare
  - Terminated by **lamina terminalis**
    - Frontal plate attached to rostrum corporis callosi
    - Continues across commissura anterior onto chiasma opticum
    - Rostral border di- and telencephalon
- **Lateral part**
  - **pars pallialis** = pallium = cerebrum = hemispheria
  - **pars basilaris** = nuclei basales = bazal ganglia
    - Deep in hemispheria
  - **pars septalis** = septum
    - Immediately in front of lamina terminalis

# Basal Nuclei [Ganglia]

## Horizontal Sections through Cerebrum



# Septum = pars septalis

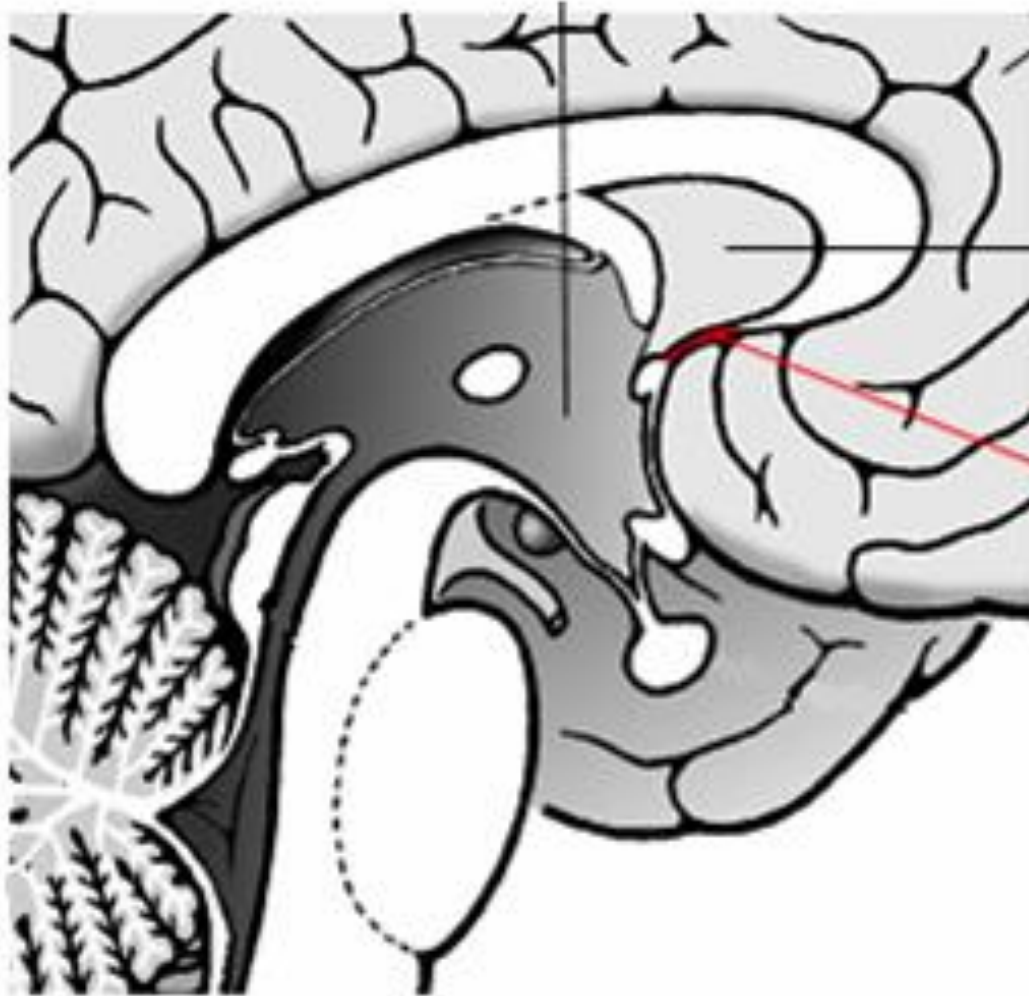
- **septum pellucidum**

- Thin dorsal part separating lateral ventricles from each other
- Extended in between columnae fornicis and anterior 1/2 corpus callosum
- paired (2 laminas), forms cavum septi pelucidi

- **septum verum**

- Bazal part of septum
- Surface projection = gyrus paraterminalis (is not thus cortical area!)
- Laterally forms medial part of cornu anterius of lateral ventricle
- Caudally ends by vertically passing commissura anterior
- function – connected with limbic system
  - Supplies acetylcholin into hippocampus (Ch1-2)
- *centrum hedonie* (= pleasure)

# III rd brain ventricle



medial wall of cornua anteriora of the lateral ventricle

**septum verum**

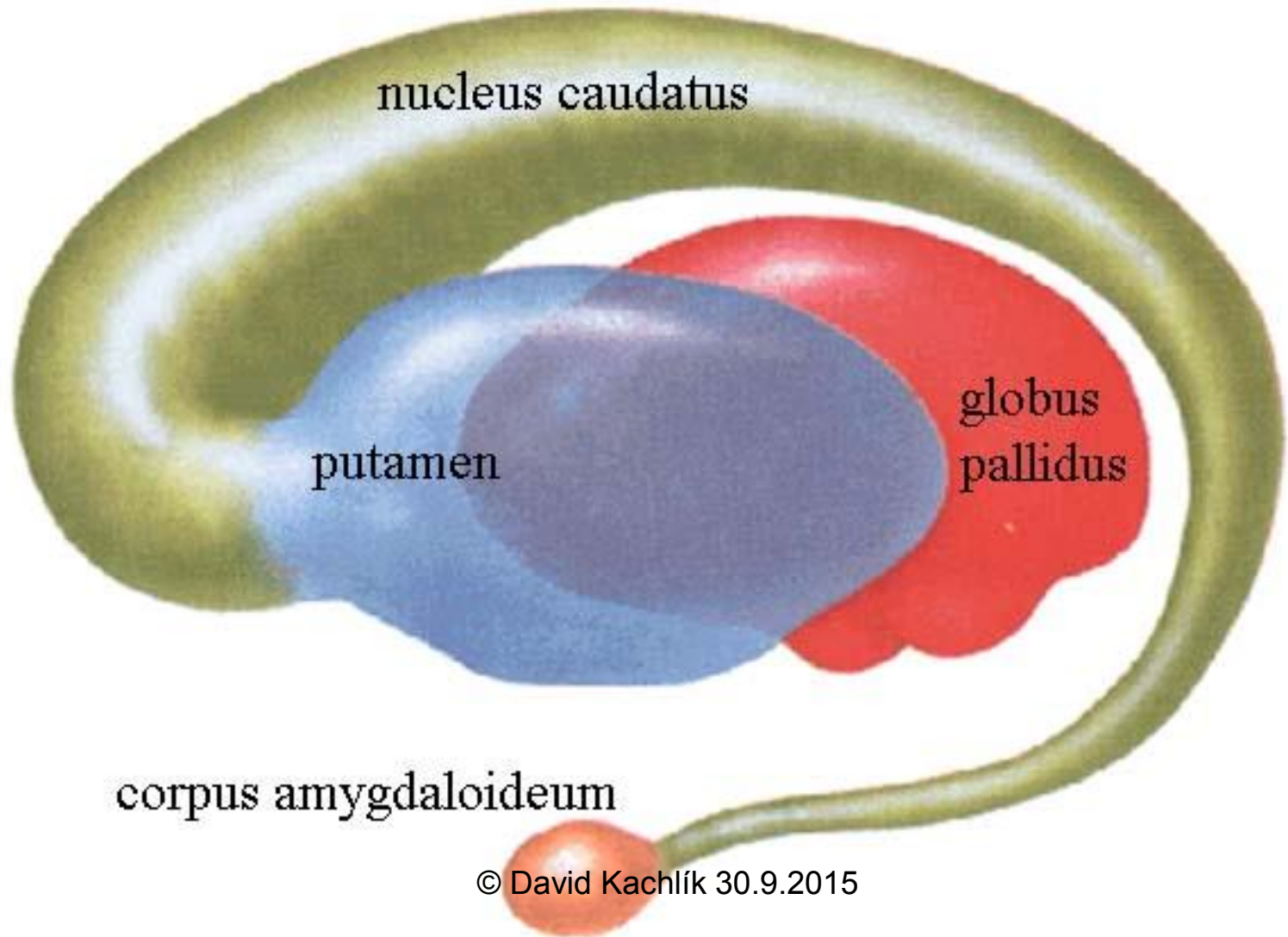
# Bazal ganglia = nuclei basales = pars basilaris telencephali

## Traditional concept of bazal ganglia

- corpus striatum = *neostriatum*
  - nucleus caudatus + putamen
- nucleus lentiformis
  - putamen + globus pallidus
- globus pallidus = *paleostriatum*
- corpus amygdaloideum = *archistriatum*

# Basal Nuclei [Ganglia] - Schema

Left Lateral View

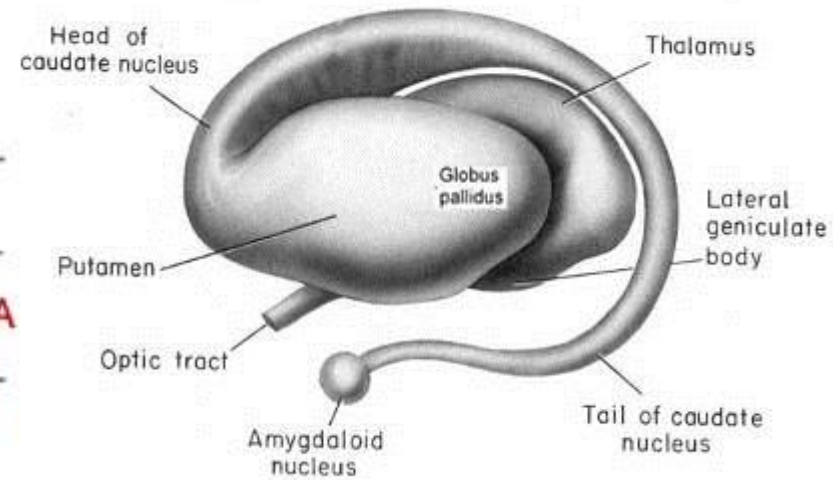
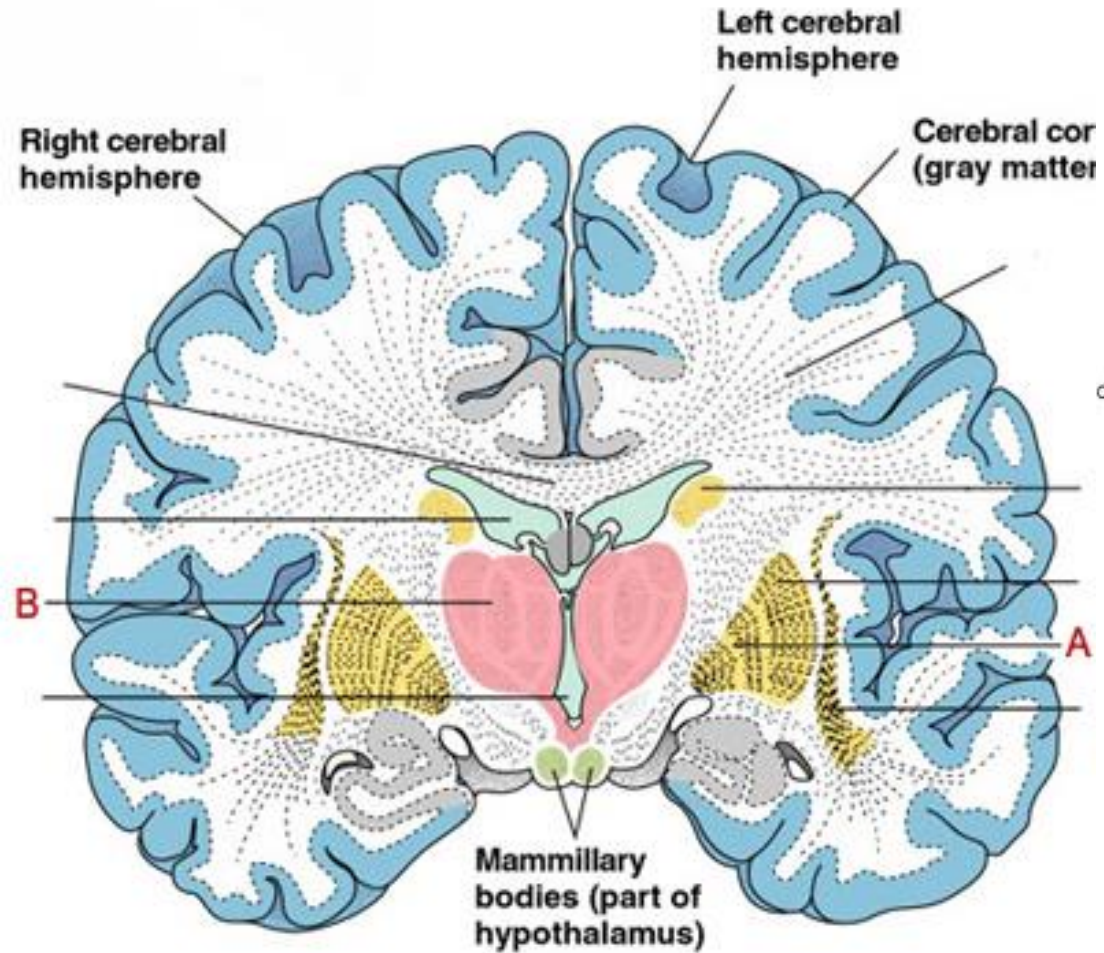


# Principal basal ganglia

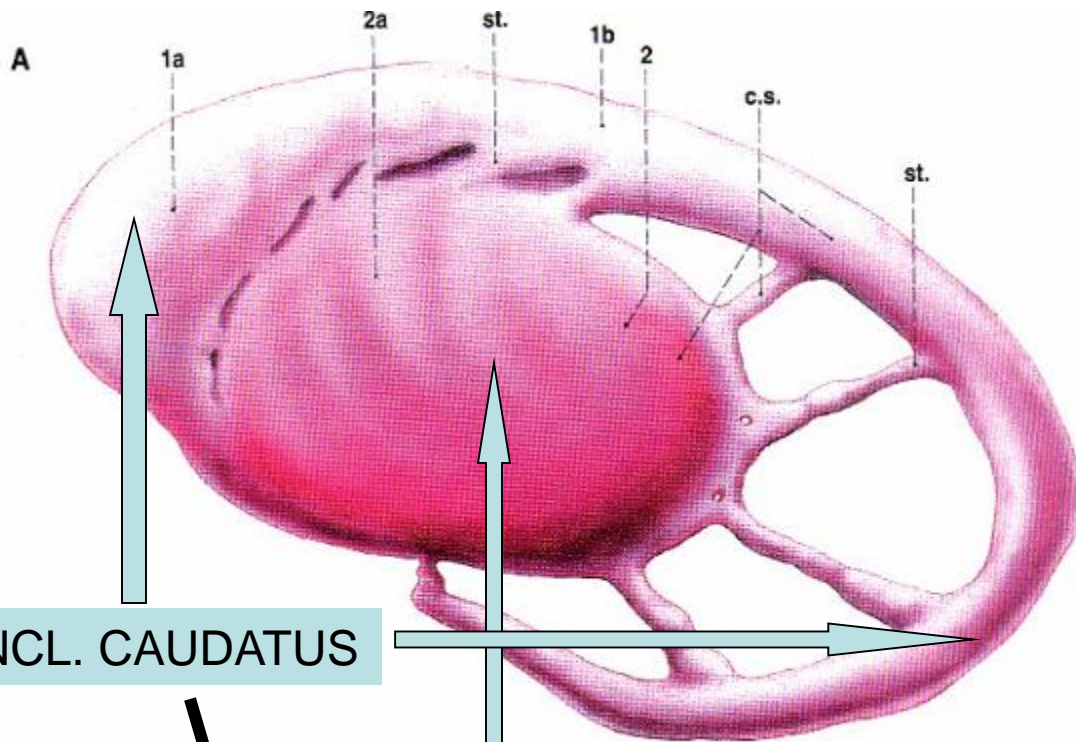
- striatum = corpus striatum
  - nucleus caudatus
  - putamen
  
- globus pallidus = pallidum
  - Medialis
  - Lateralis



# Nuclei basales



# Nuclei basales

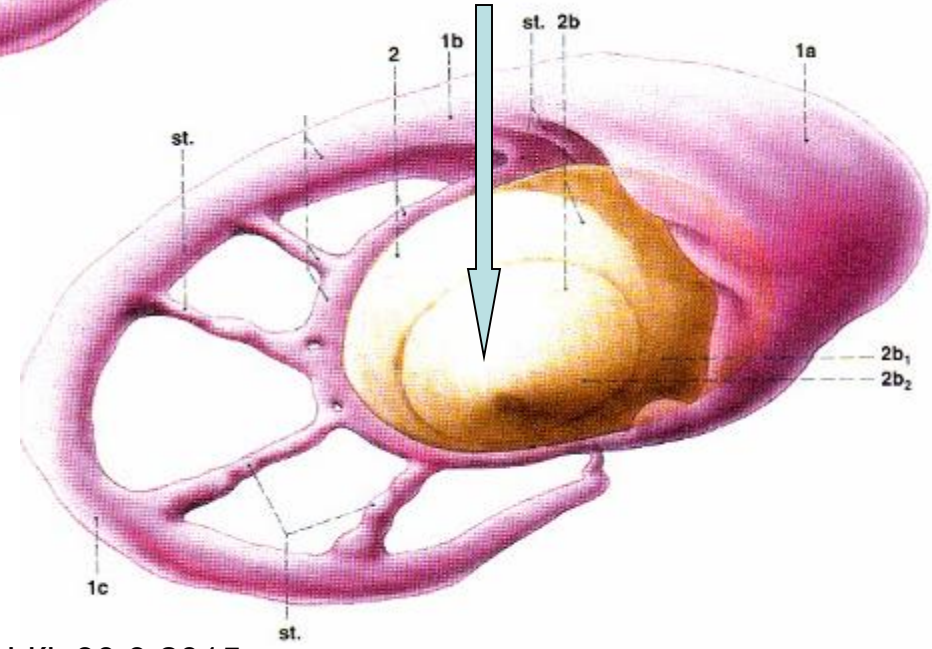


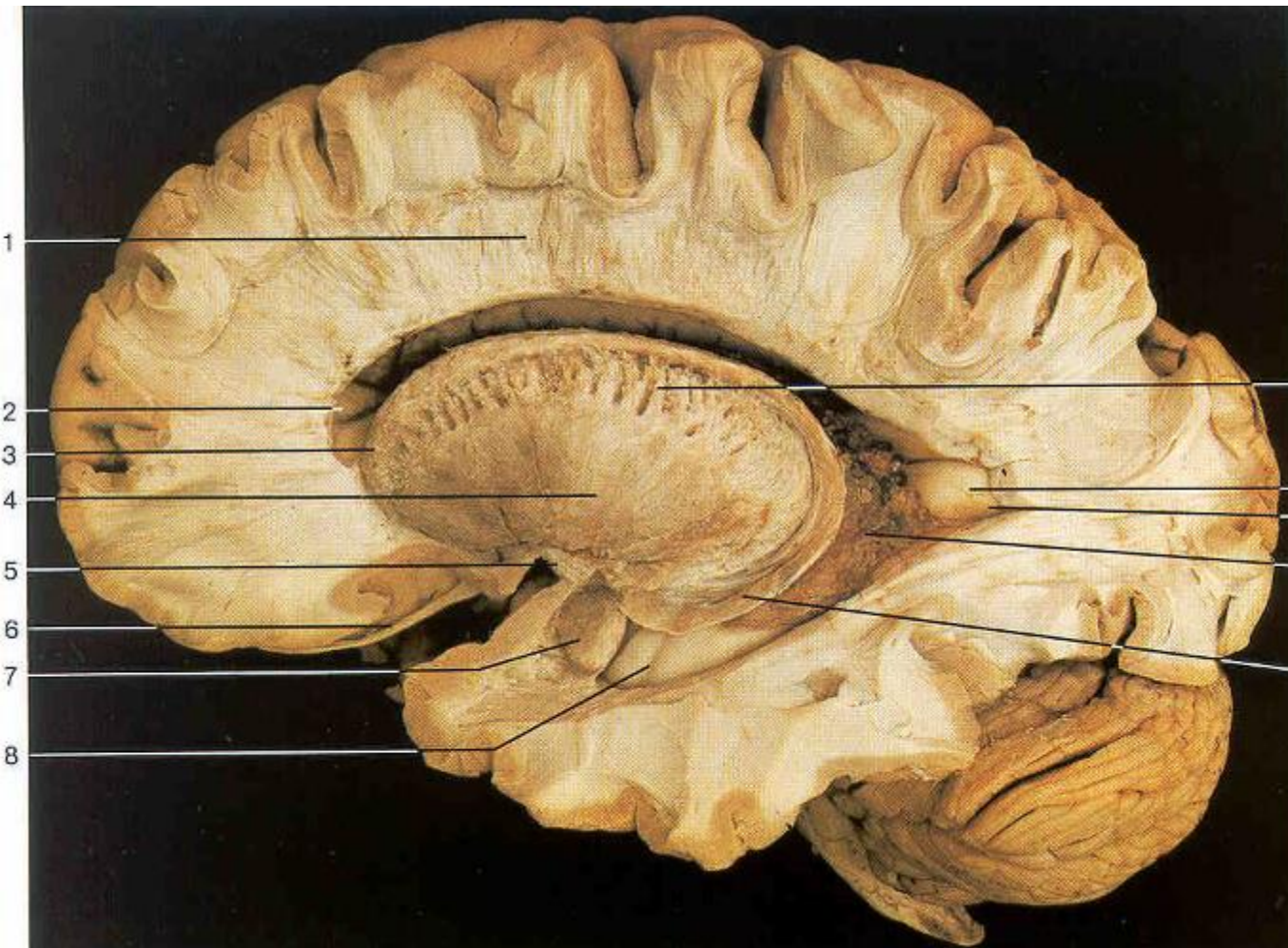
NCL. CAUDATUS

GLOBUS PALLIDUS

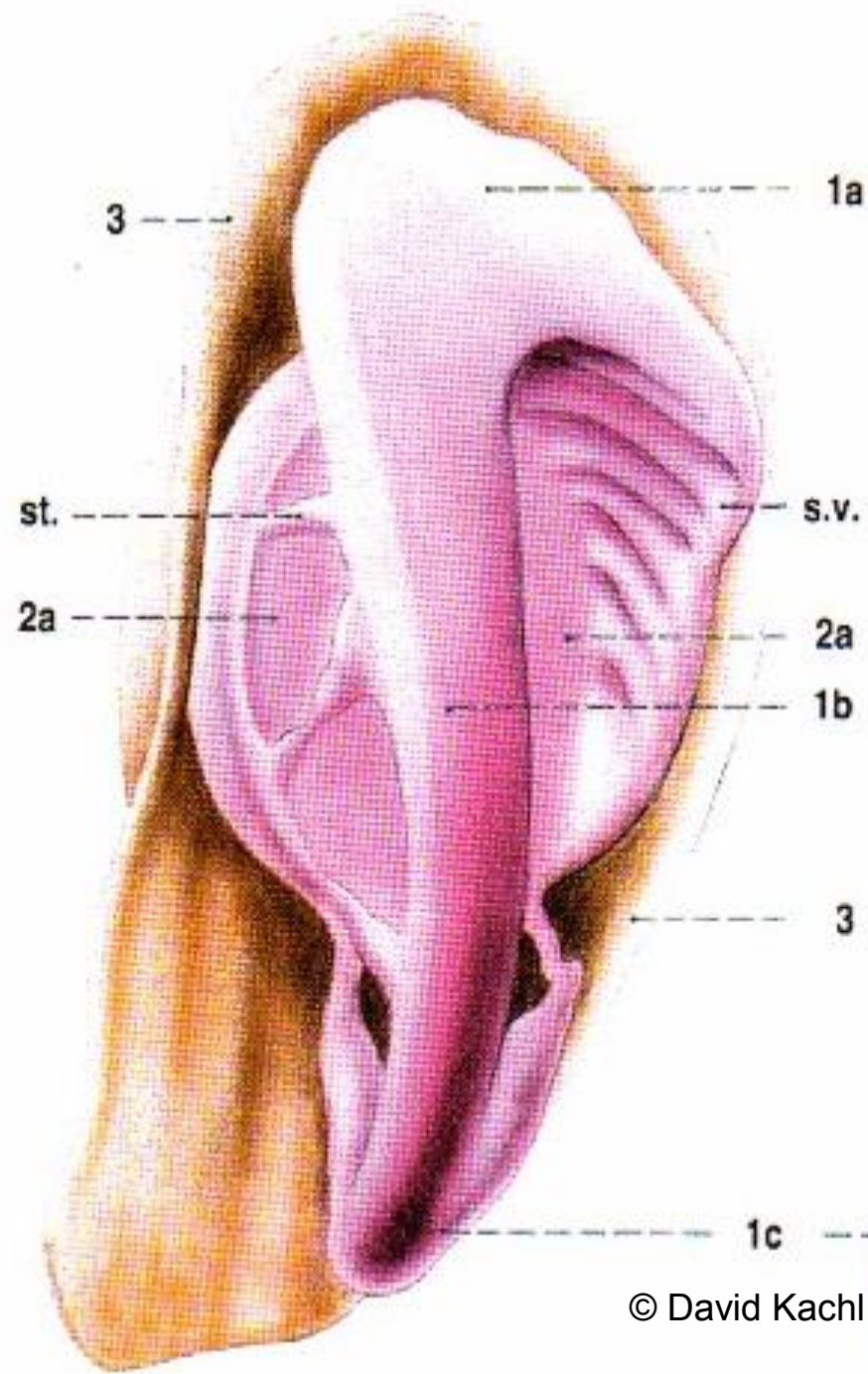
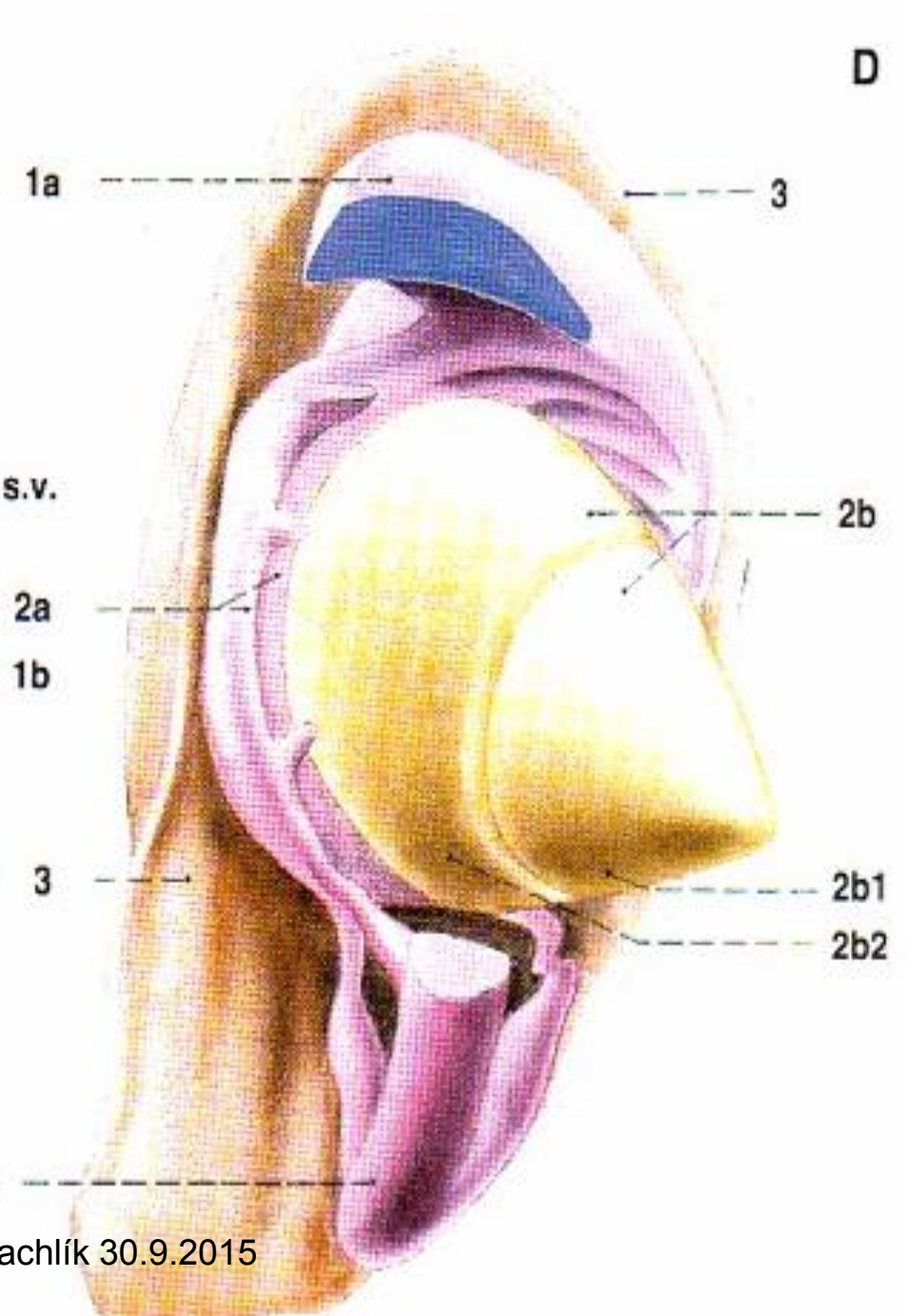
PUTAMEN

STRIATUM





- 1 corona radiata
- 2 cornu ant. ventriculi lat.
- 3 caput **nuclei caudati**
- 4 **putamen** (ncl. lentiformis)
- 5 commissura ant.
- 6 tractus olfactorius
- 7 **corpus amygdaloideum**
- 8 digitationes hippocampi
- 9 capsula int.
- 10 calcar avis
- 11 cornu post. ventriculi lat.
- 12 plexus choroideus
- 13 cauda nuclei caudati
- 14 **thalamus**
- 15 fibrae arcuatae cerebri
- 16 globus pallidus (zvyšok)

**C****D**

# Other basal ganglia

- ncl. subthalamicus (corpus Luysi)
- substantia nigra
  - pars compacta (A9)
  - pars reticularis
- substantia innominata Reicherti
  - *limbic function*
  - centromedial part of corpus amygdaloideum
  - ncl. basalis Meynerti (Ch4)
  - striatum ventrale = nucleus accumbens
  - pallidum ventrale
- ncl. subbrachialis (area ventralis tegmentalis Tsai, A10)

# Bazal ganglia (nuclei basales)

Basic function: production of motor patterns

**striatum = corpus striatum = neostriatum**

- nucleus caudatus (caudate nucleus)
  - caput, corpus, cauda
  - Follows lateral ventricle
  - AF: association cortex, caput mostly from prefrontal cortex (*cognitive function*)
- putamen (shell)
  - AF: motor cortex
  - Connected with ncl. caudatus via
    - striae (vertically via capsula interna)
    - ncl. accumbens (seпти) (ventrobazally)
  - Morphologically creates with globus pallidus nucleus lentiformis
  - Irritation leads to hedony (similar to heroin users) = plenty of dopamin from area ventralis Tsai 😊

# BAZAL GANGLIA (NUCLEI BASALES)

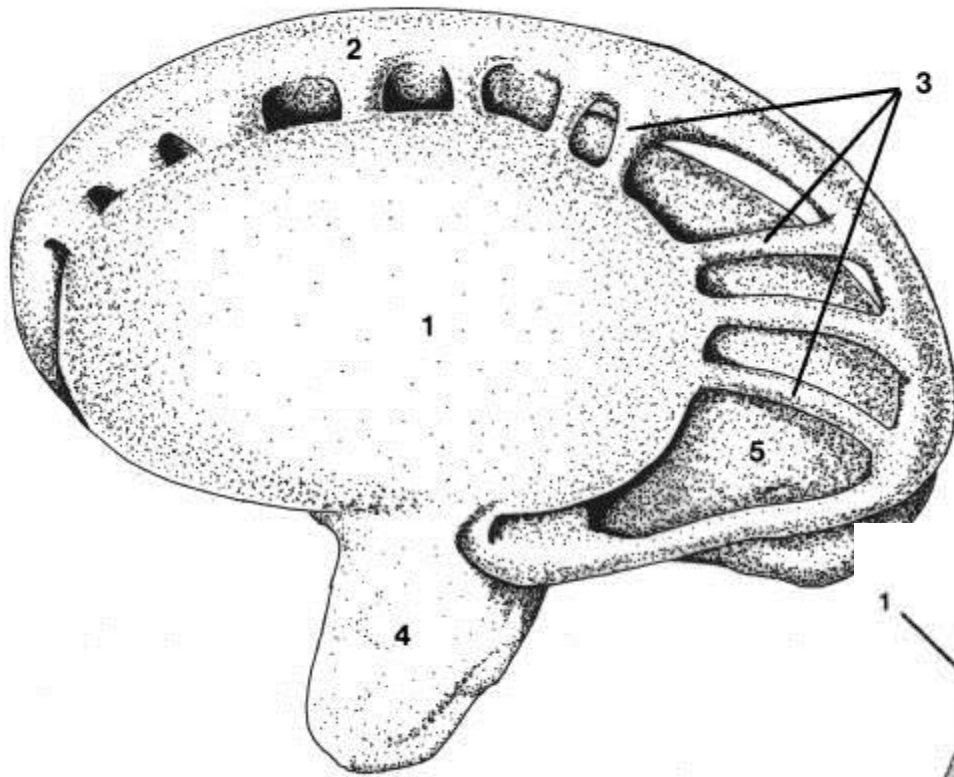
Basic function: production of motor patterns

*defect:*

- Involuntary movements **athetoid** (= slow, spiral, crawling, climbing), muscular hypotony
- Involuntary movements **choreatic** (= fast, useless and irregular movements of tongue, mimic muscles and muscles of UL), muscular hypotonia

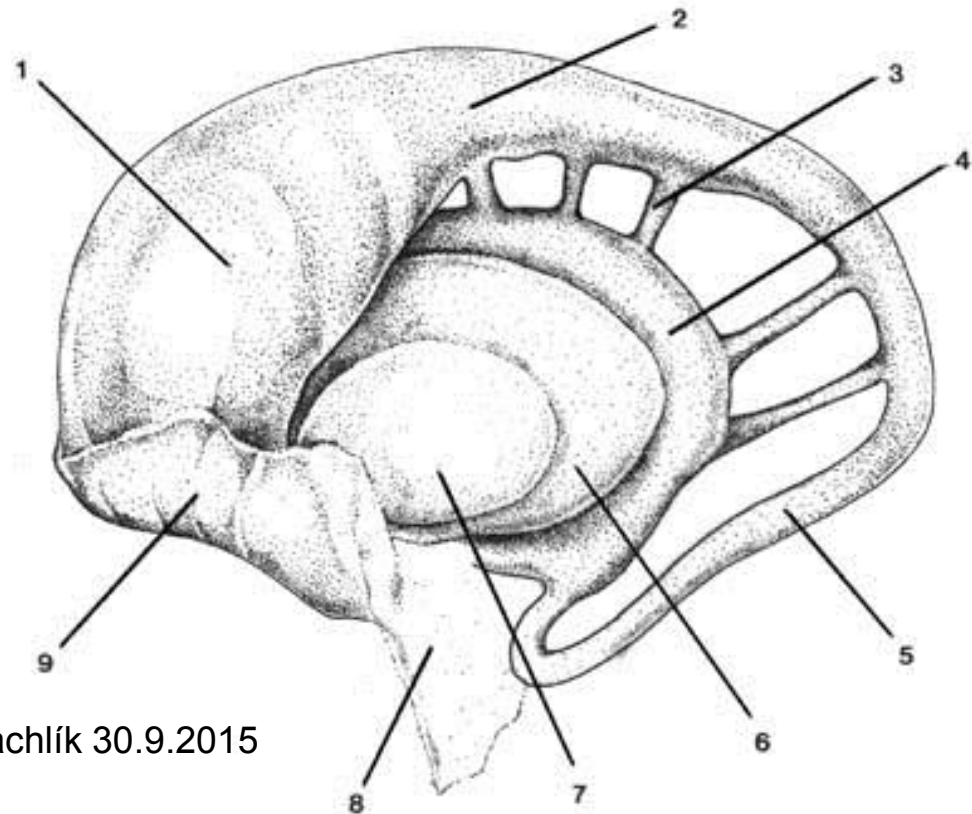
*Striatum ventrale* = nucleus accumbens + small part of striatum ventrale (basally) from commissura anterior

- Afferentation from limbic cortex, hypothalamus and amygdala



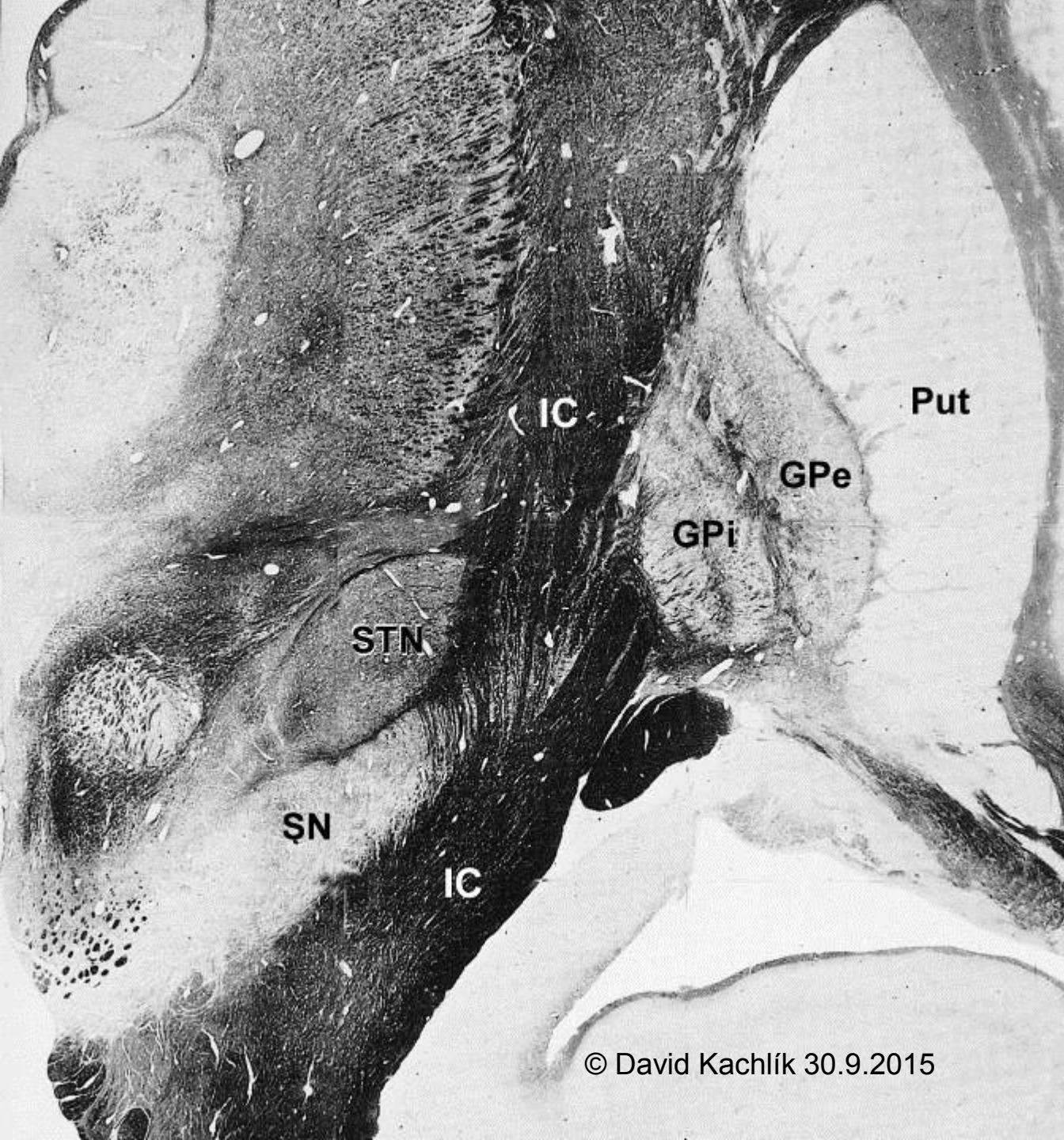
↑ **Lateral surface of basal ganglia**

**Medial surface of basal ganglia ↓**





# BAZAL GANGLIA



Nucleus caudatus

Putamen

Globus pallidus

lateralis

medialis

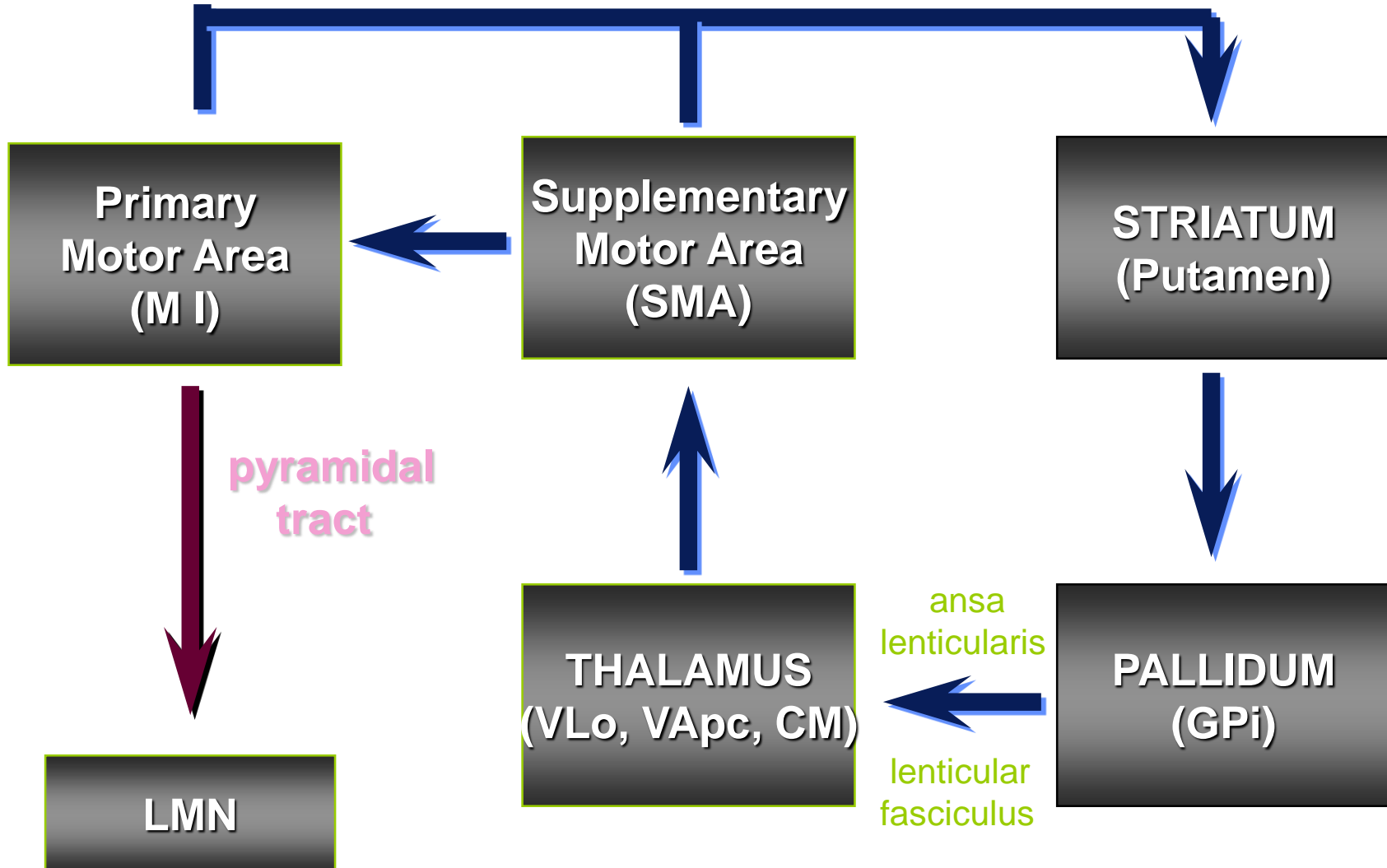
Nucleus

subthalamicus

Substantia nigra

*Capsula interna*

# Basal Ganglia (Main Motor Circuit) - Connections



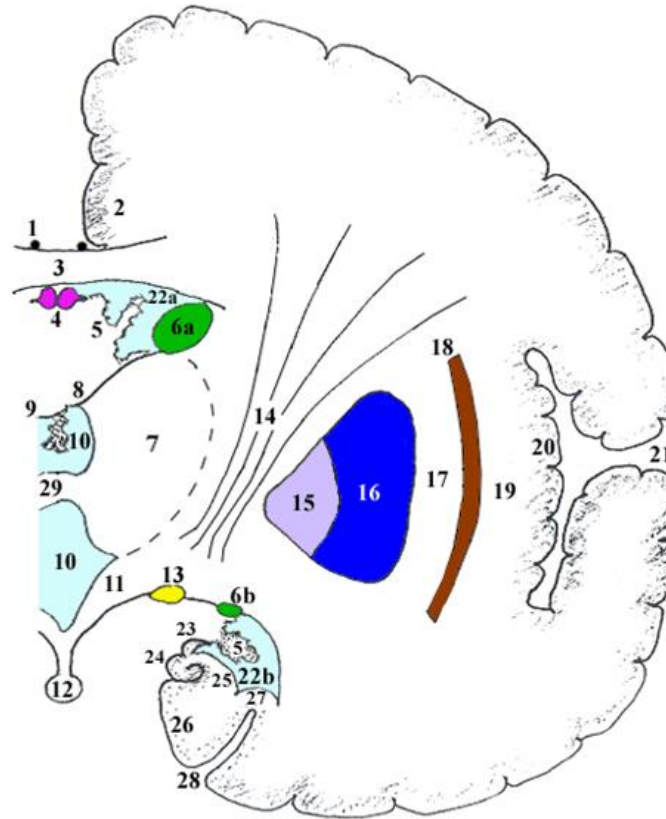
# Basal Nuclei [Ganglia]

## Horizontal Sections through Cerebrum



# TELENCEPHALON

frontal section at the level of hypophysis cerebri



- 1 - striae longitudinales corporis callosi
- 2 - gyrus cinguli
- 3 - truncus corporis callosi
- 4 - corpus fornix
- 5 - tela choroidea ventriculi lateralis
- 6a - corpus nuclei caudati
- 6b - cauda nuclei caudati
- 7 - thalamus
- 8 - stria medullaris + taenia thalami
- 9 - tela choroidea ventriculi tertii
- 10 - ventriculus tertius
- 11 - hypothalamus
- 12 - hypophysis (glandula pituitaria)
- 13 - tractus opticus
- 14 - capsula interna

- 15 - globus pallidus
- 16 - putamen
- 17 - capsula externa
- 18 - claustrum
- 19 - capsula extrema
- 20 - lobus insulae
- 21 - fissura lateralis cerebri /Sylvii/
- 22a - pars centralis ventriculi lateralis
- 22b - cornu temporale ventriculi lateralis
- 23 - fimbria hippocampi
- 24 - gyrus dentatus
- 25 - hippocampus
- 26 - gyrus parahippocampalis
- 27 - cuneus collateralis
- 28 - sulcus collateralis
- 29 - adhesio interthalamica

# BAZAL GANGLIA (NUCLEI BASALES)

## Globus pallidus

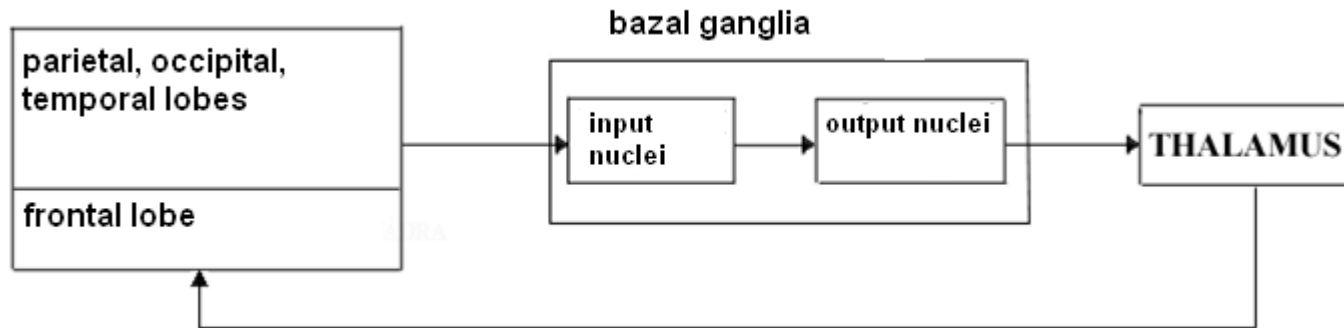
- globus pallidus medialis + lateralis
  - Separated by lamina medullaris interna
  - Developmentally originate from subthalamus, from which it is separated by capsula interna
  - efferentation: GPM → fasciculus + ansa lenticularis → fasciculus thalamicus → thalamus
  - GPL → fasciculus subthalamicus → ncl. subthalamicus
- lesion:* reduction or loss of locomotion, speech, lethargy or cataplexy

*Pallidum ventrale* = small part of globus pallidus reaching ventrally (basally) from commissura anterior

*Nucleus lentiformis* = putamen + globus pallidus

- *Morphological name!*
- Separated by lamina medullaris externa

# Basic functional connection of telencephalon



## Input nuclei

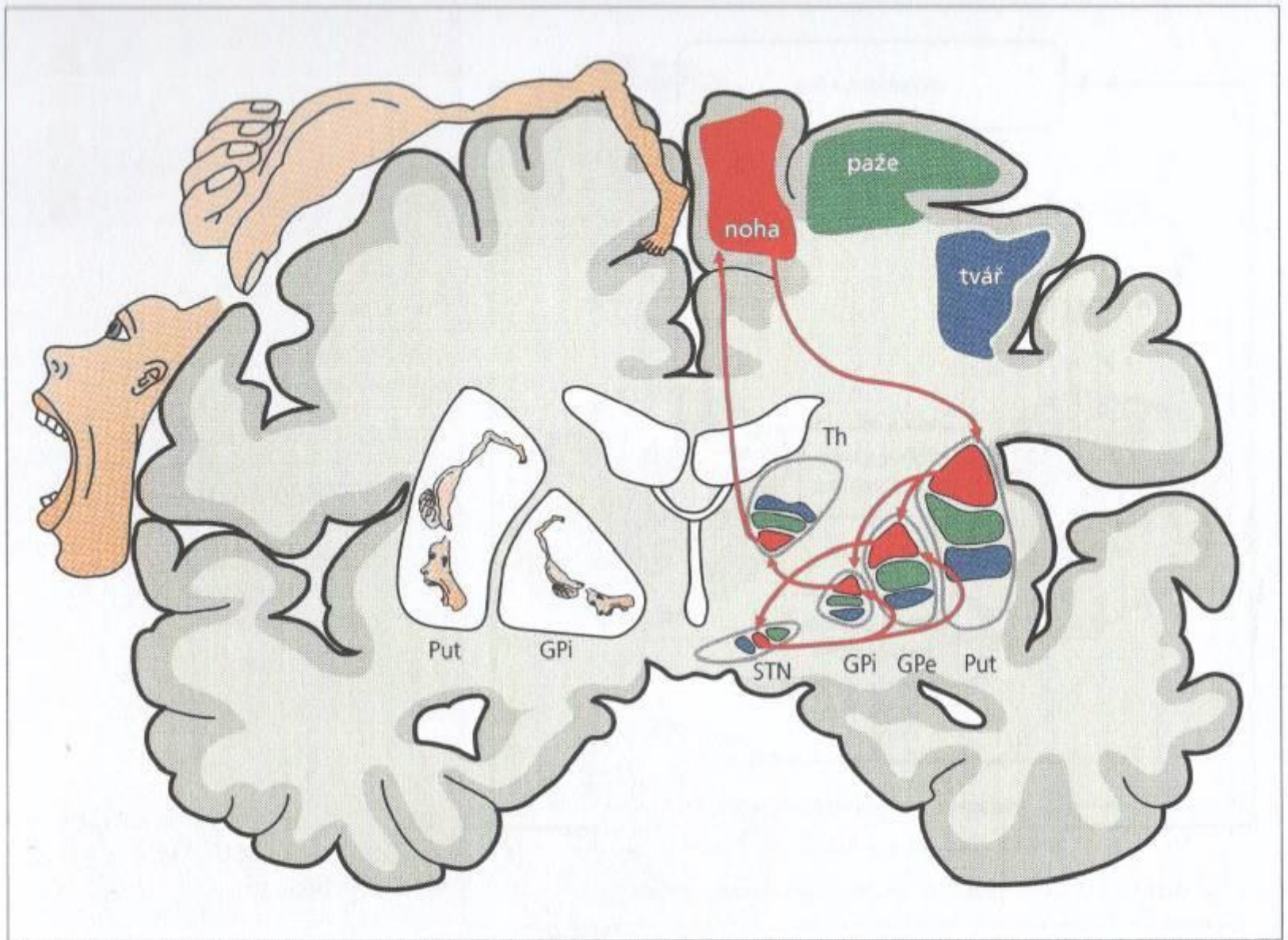
- nucleus caudatus
- putamen
- nucleus accumbens

## Output nuclei

- pars reticularis substantiae nigrae
- globus pallidus medialis
- pallidum ventrale

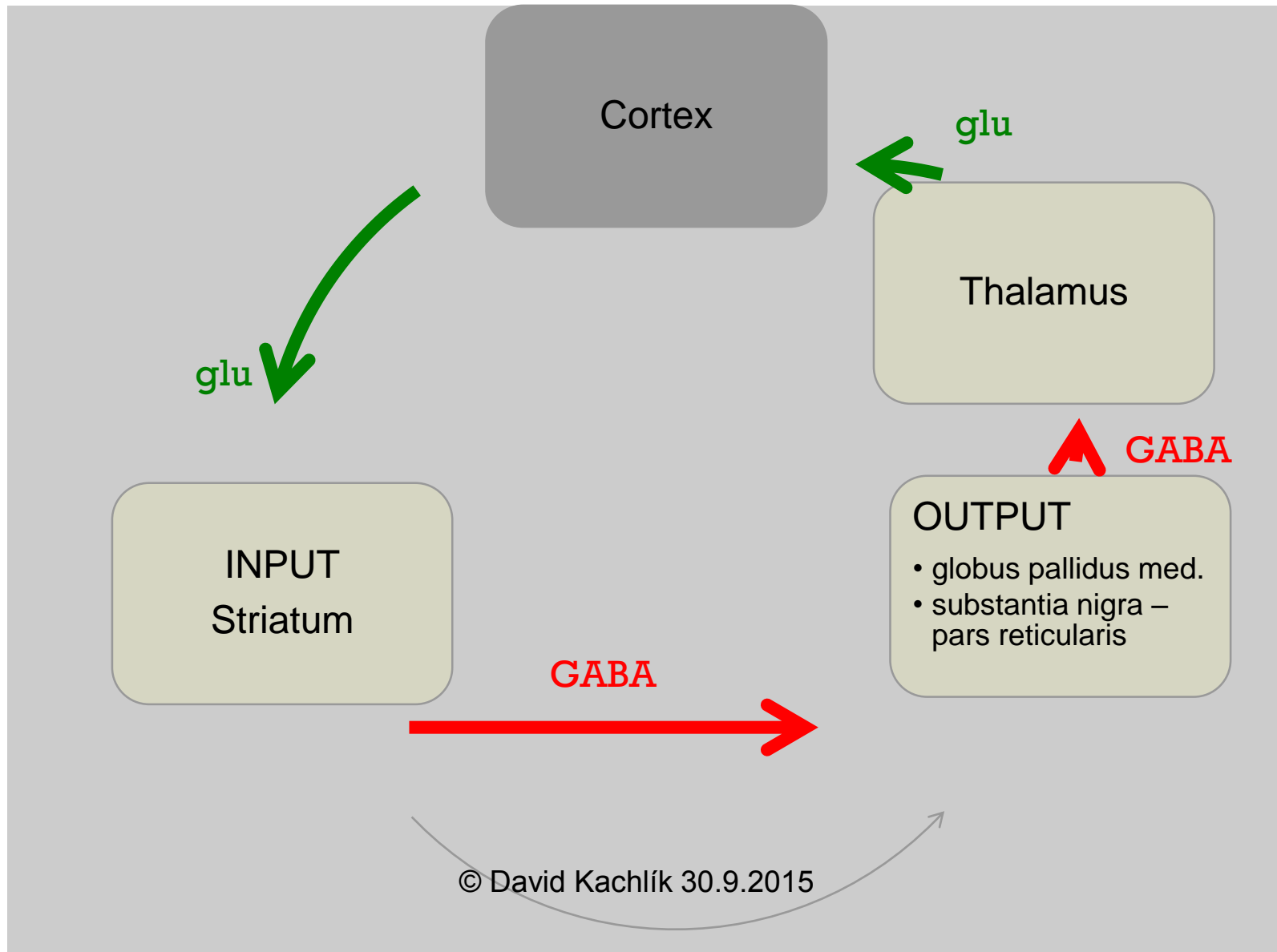
## Internal (intestitial) nuclei

- globus pallidus lateralis
- nucleus subthalamicus
- pars compacta substantiae nigrae
- area tegmentalis ventralis (ncl. subbrachialis)

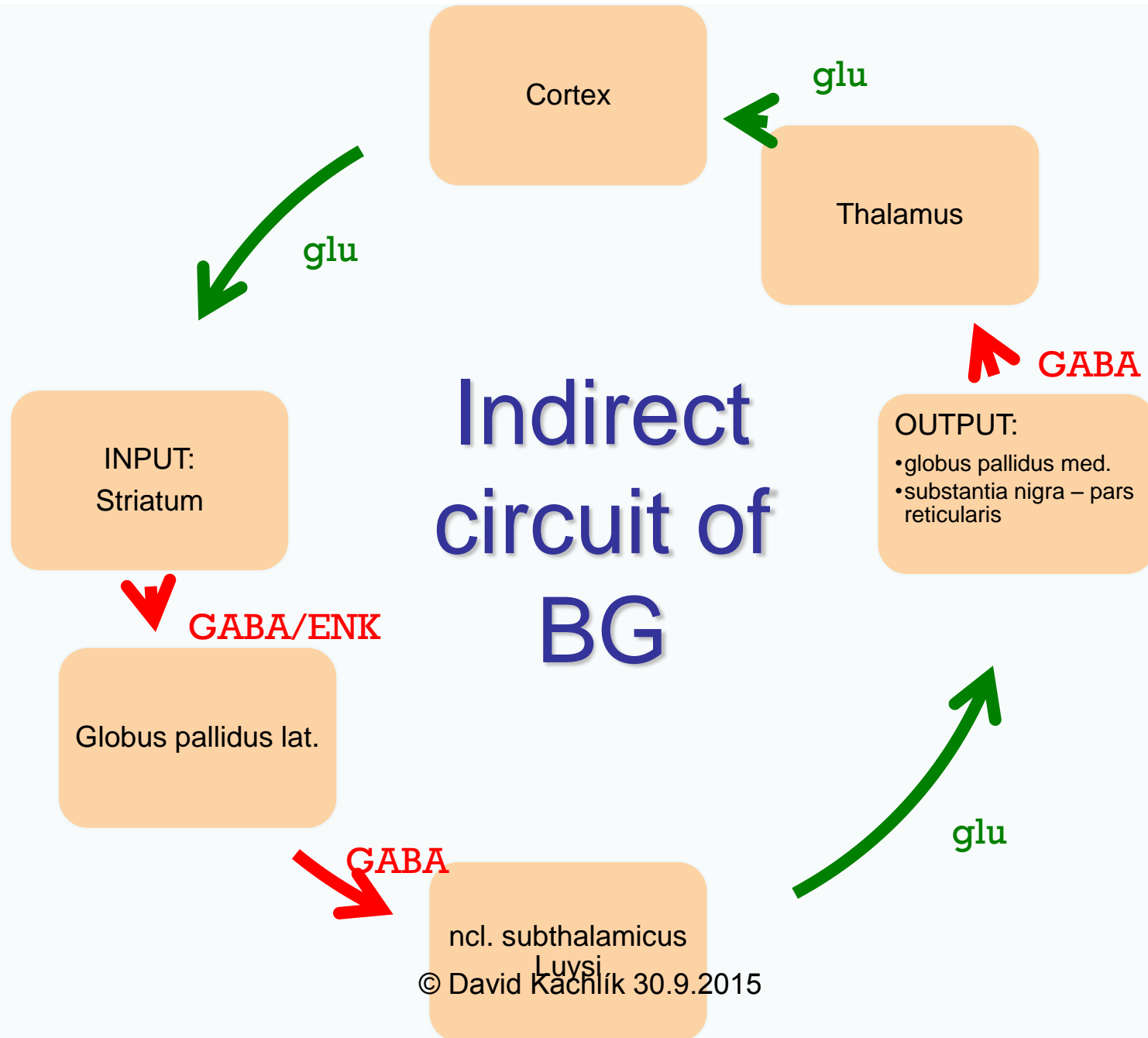


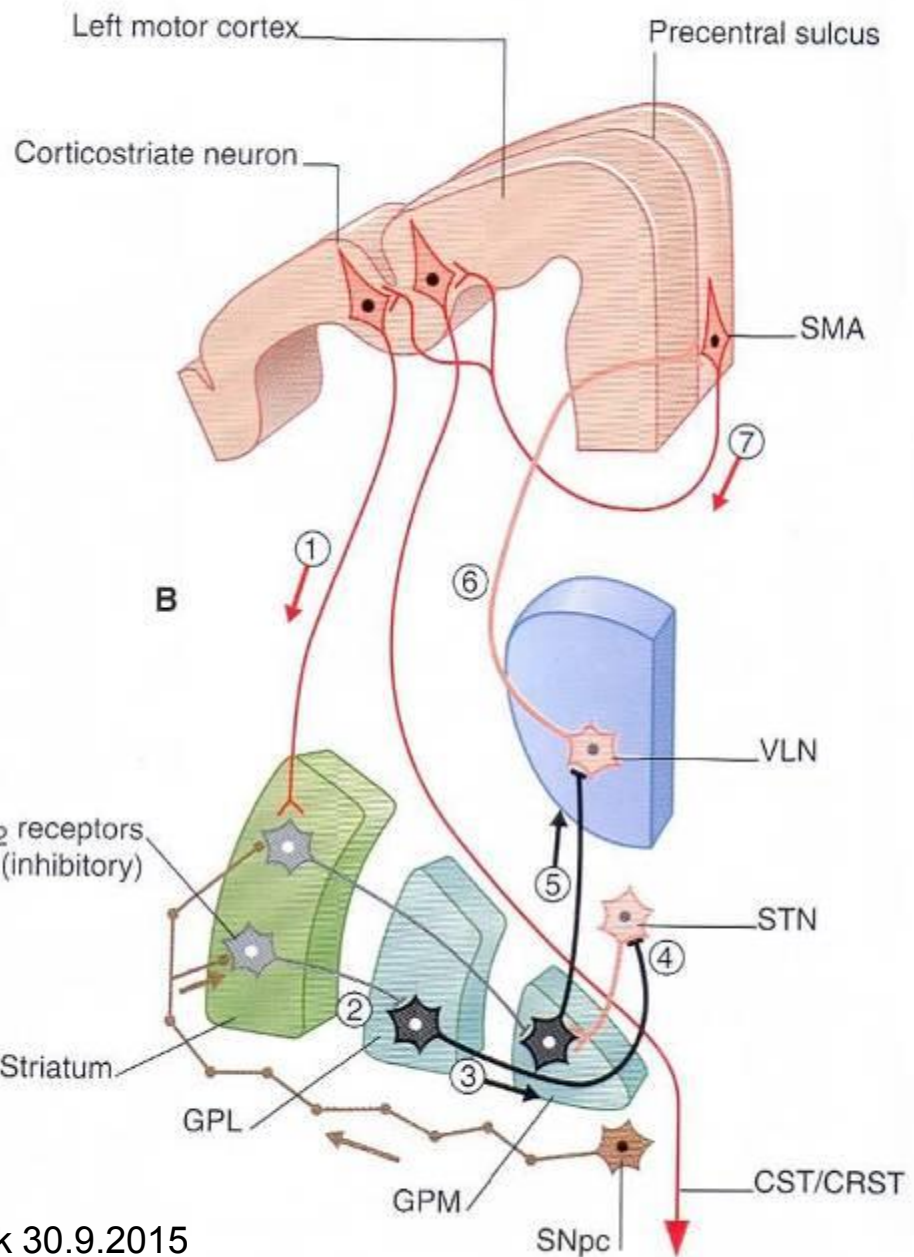
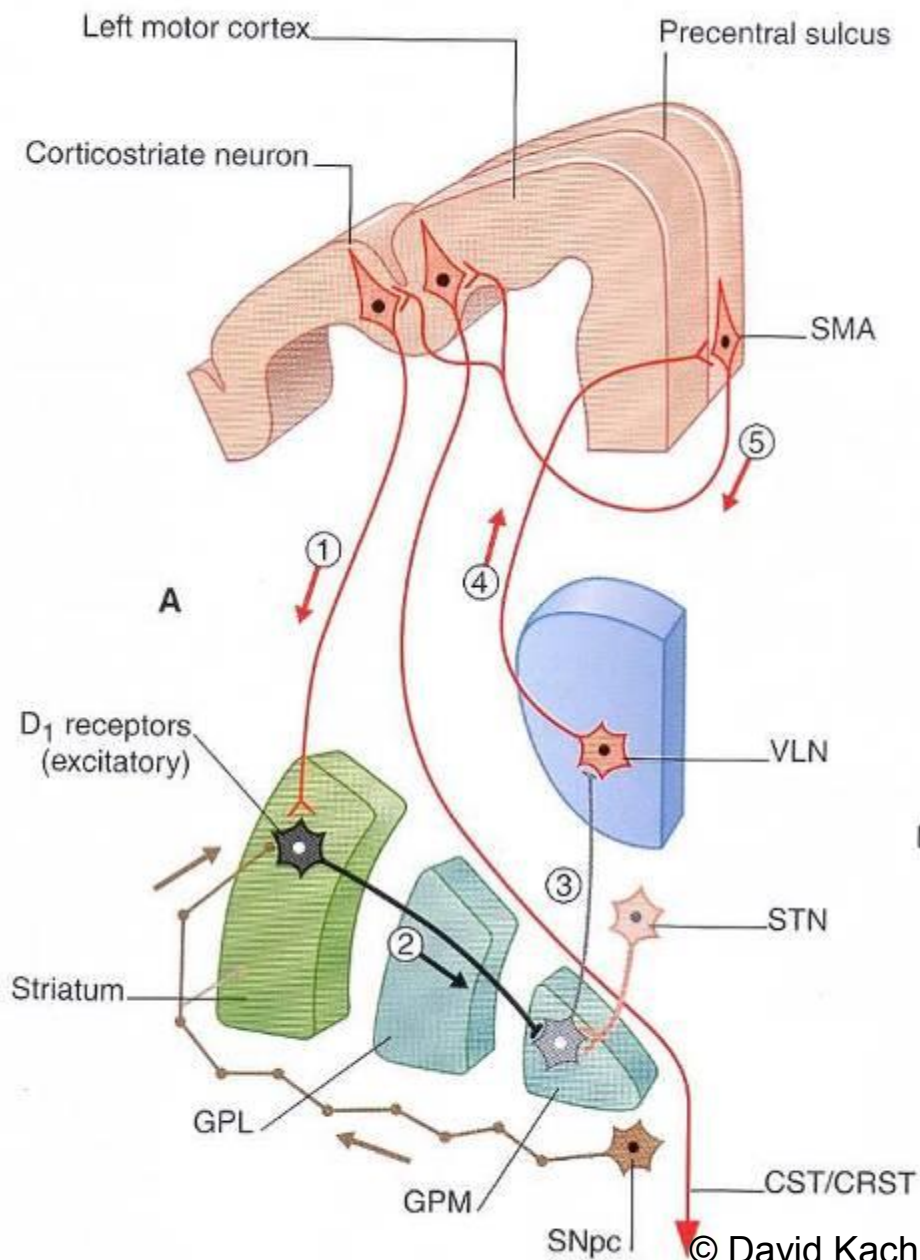
**Obr. 7.3.** Somatotopické uspořádání bazální ganglií se podobá motorické korové reprezentaci – »homunculo«*vi*. GPe = globus pallidus pars externa, GPI = globus pallidus, Put = putamen, pars interna, STN = nc. subthalamicus (David Kachník (přeloženo podle Corso et al., 2008))

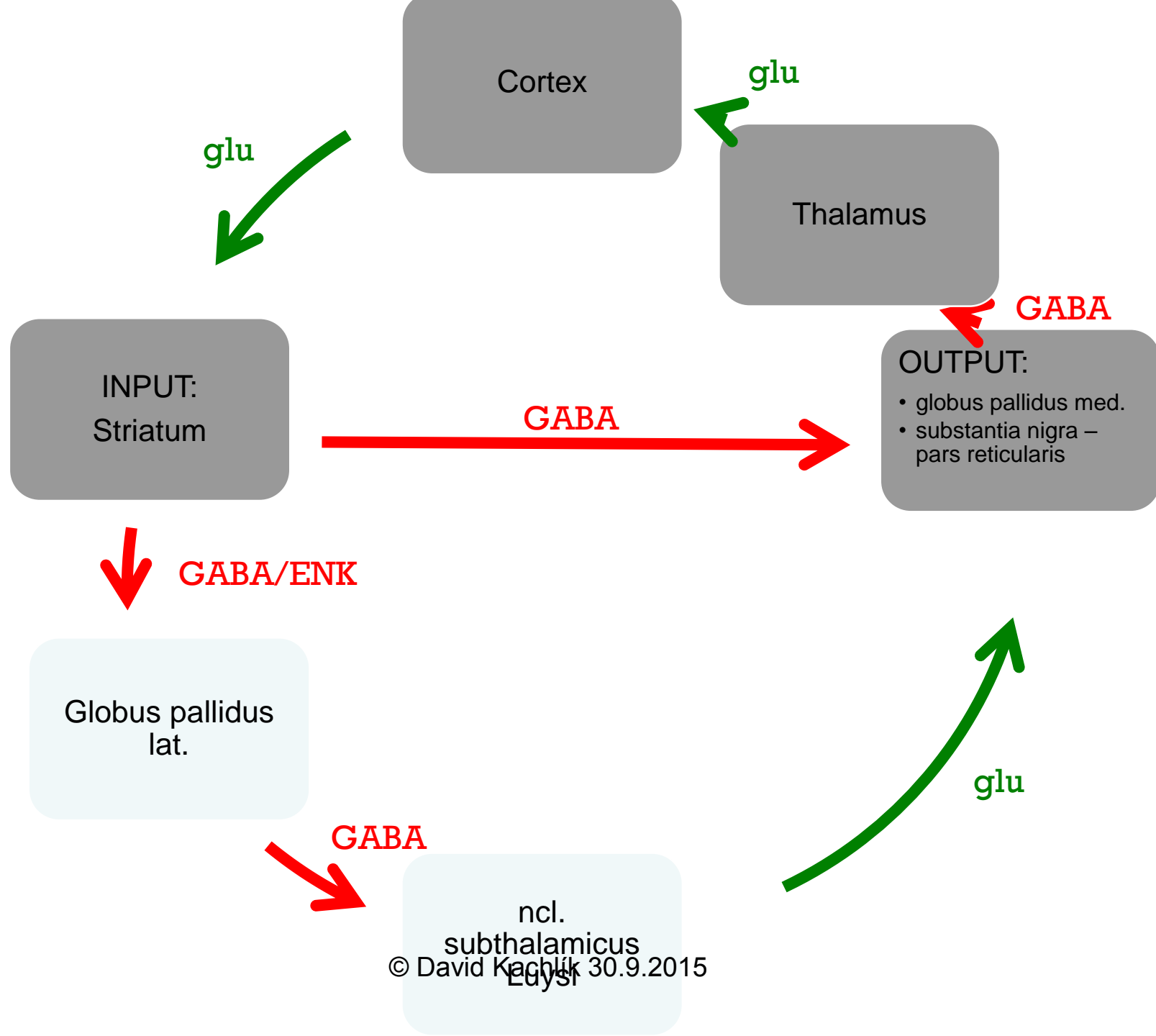
# Direct circuit of BG

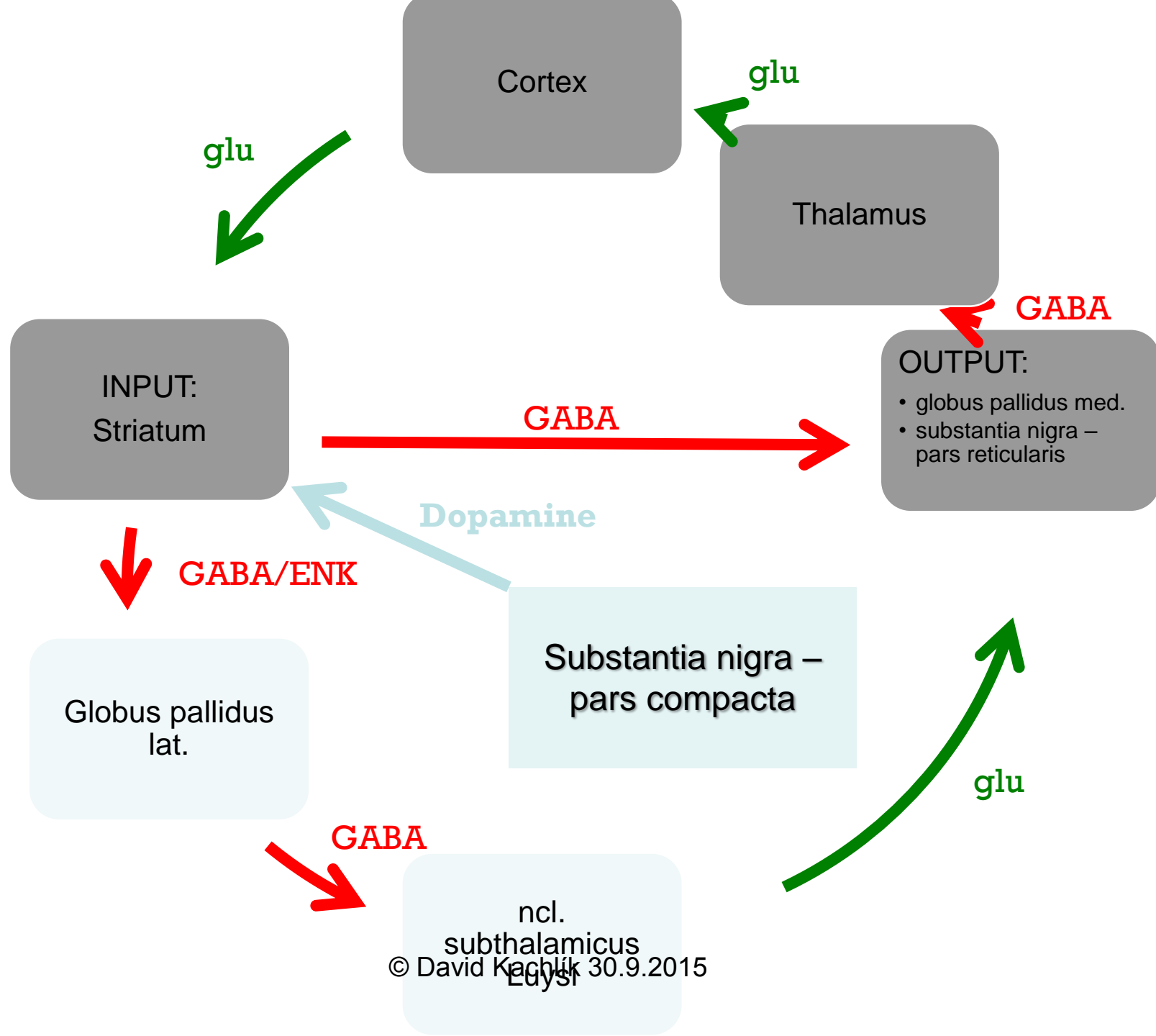


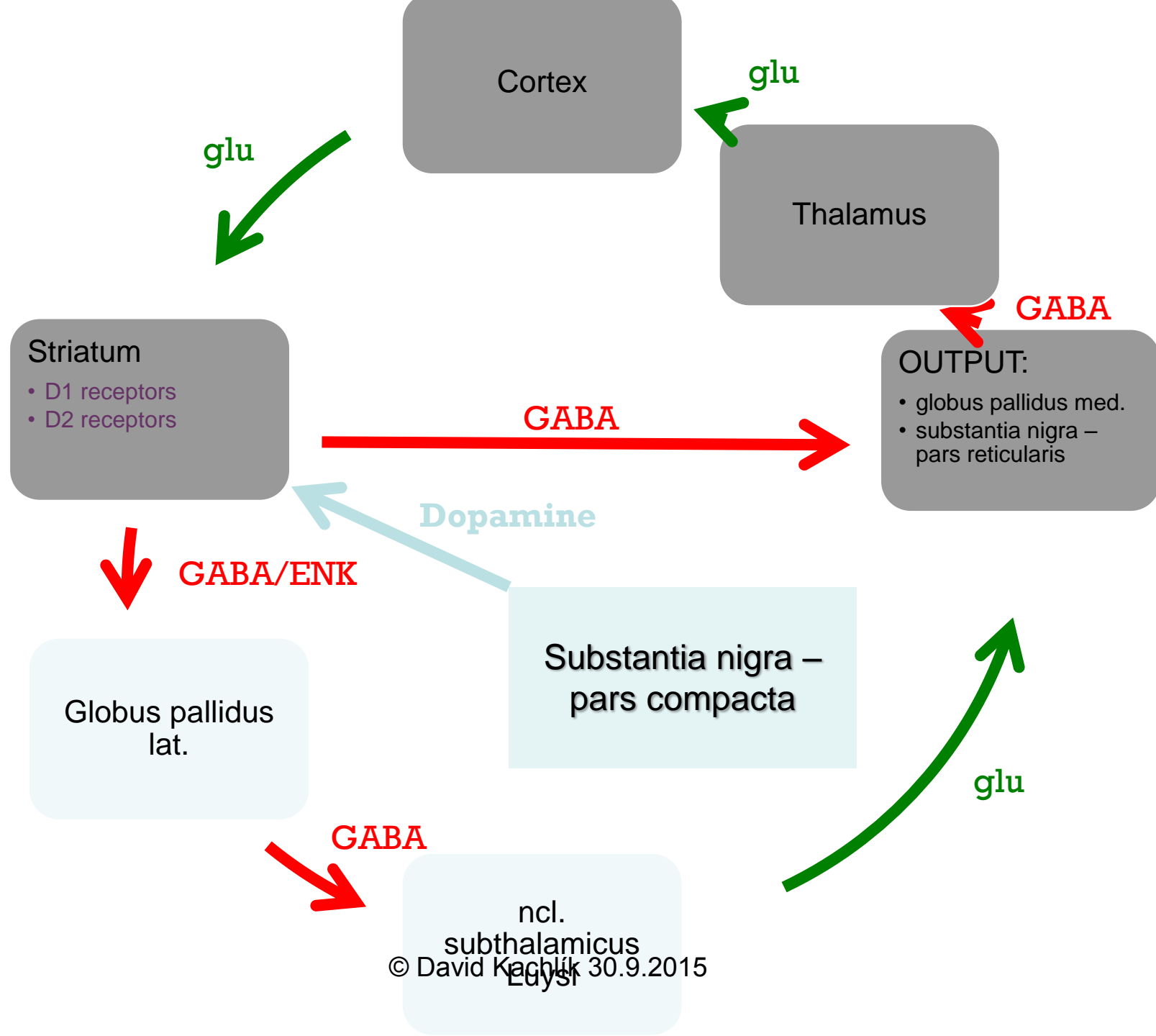


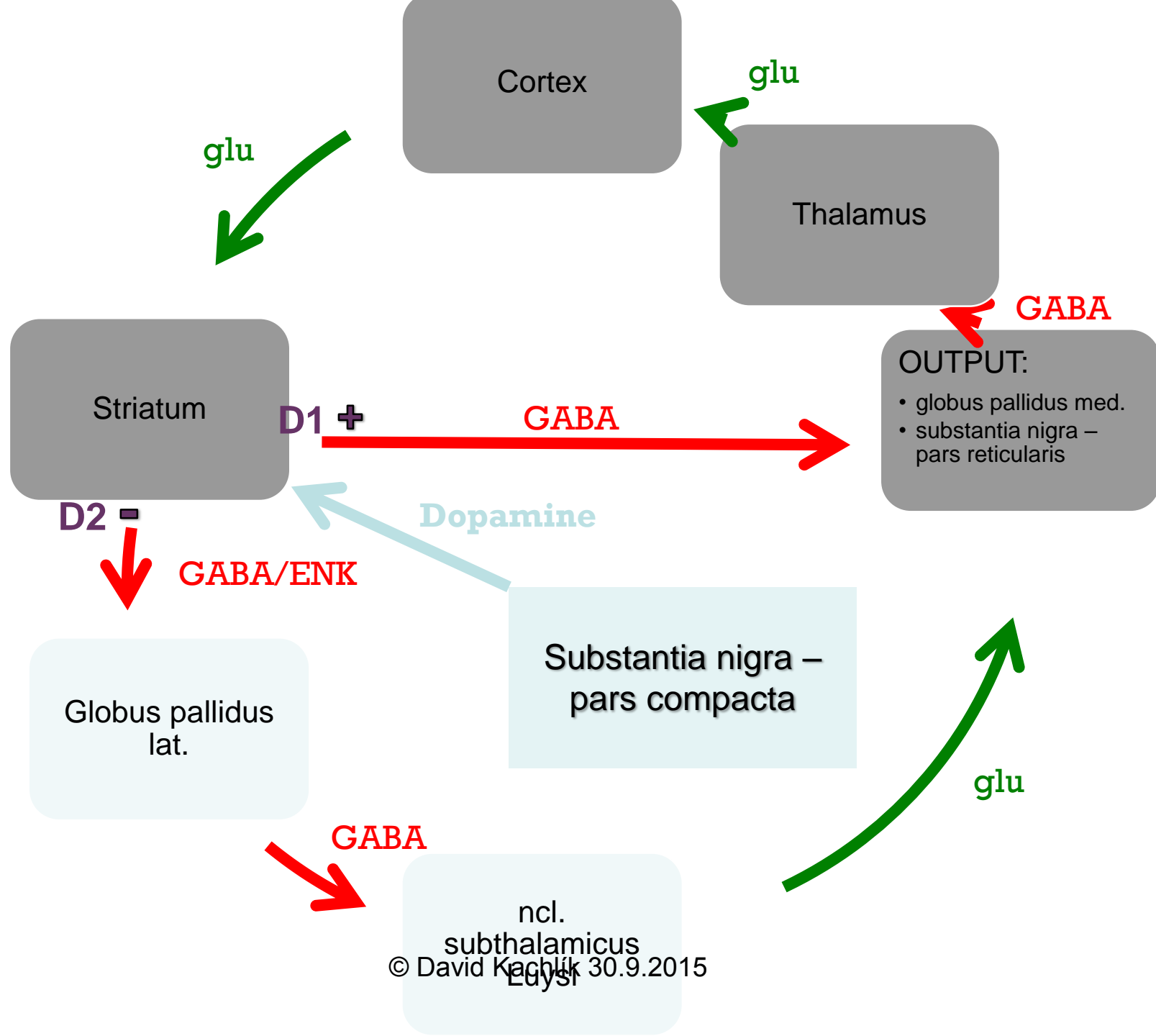


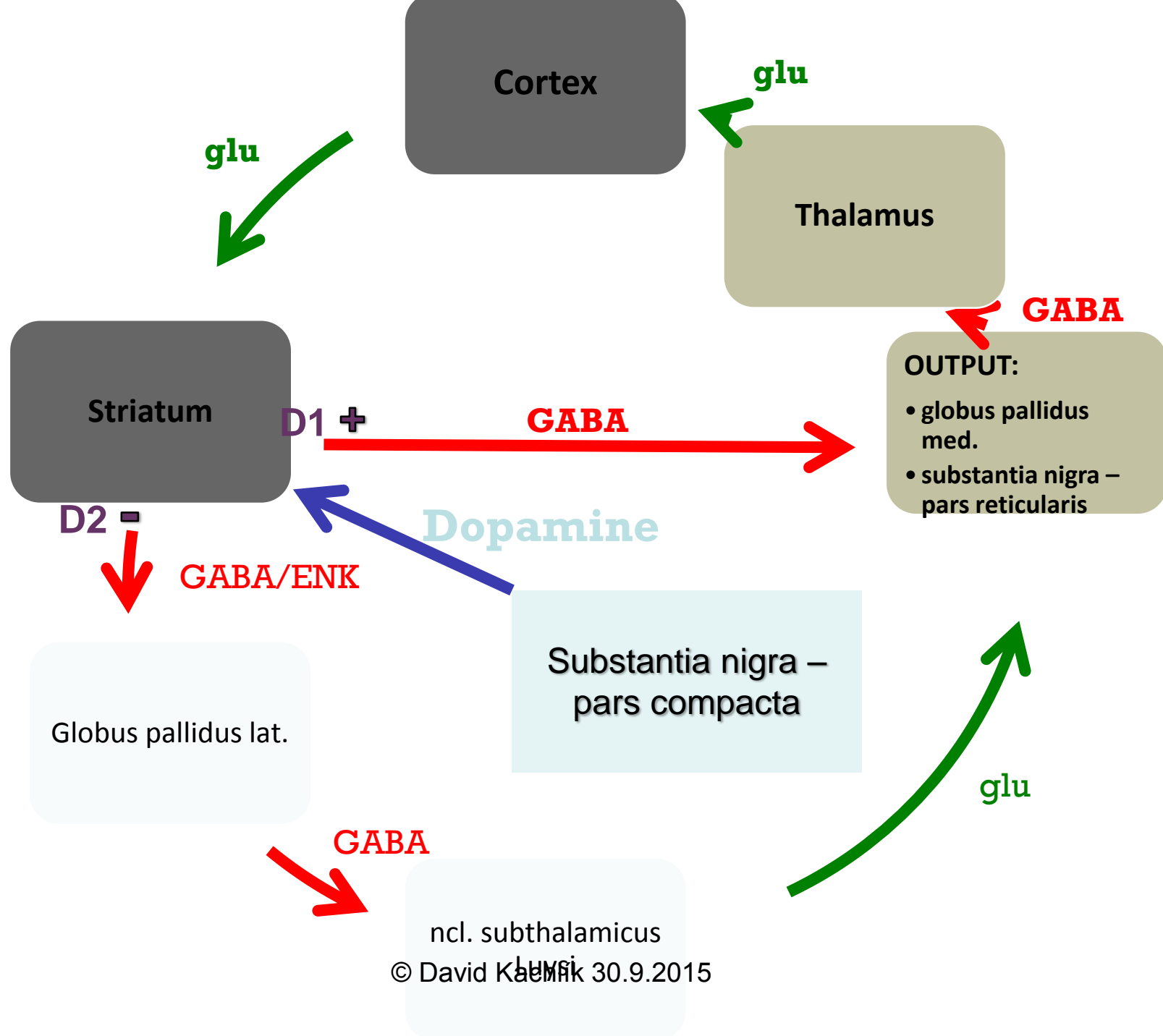












# Function of motor circuit: difference in quiet and movement

## In quiet (motor inhibition)

- **1. Nigrostriatic dopaminergic** tract is in quiet active. Dopaminergic activity is sufficient for inhibition of spontaneous motoric activity of BG.
- **2. Inhibitory effect also have GABA-ergic neurons of pallidum.**
  - Inhibitory pallidum is spontaneously active and thus is inhibited activity off thalamic motor nuclei and thus motor cortex activity. If lesion of inhibitory tracts there are involuntary movements → „dance of Saint Vitus“ (Huntingtons chorea)
- **3. decreased activity of motor thalamus**

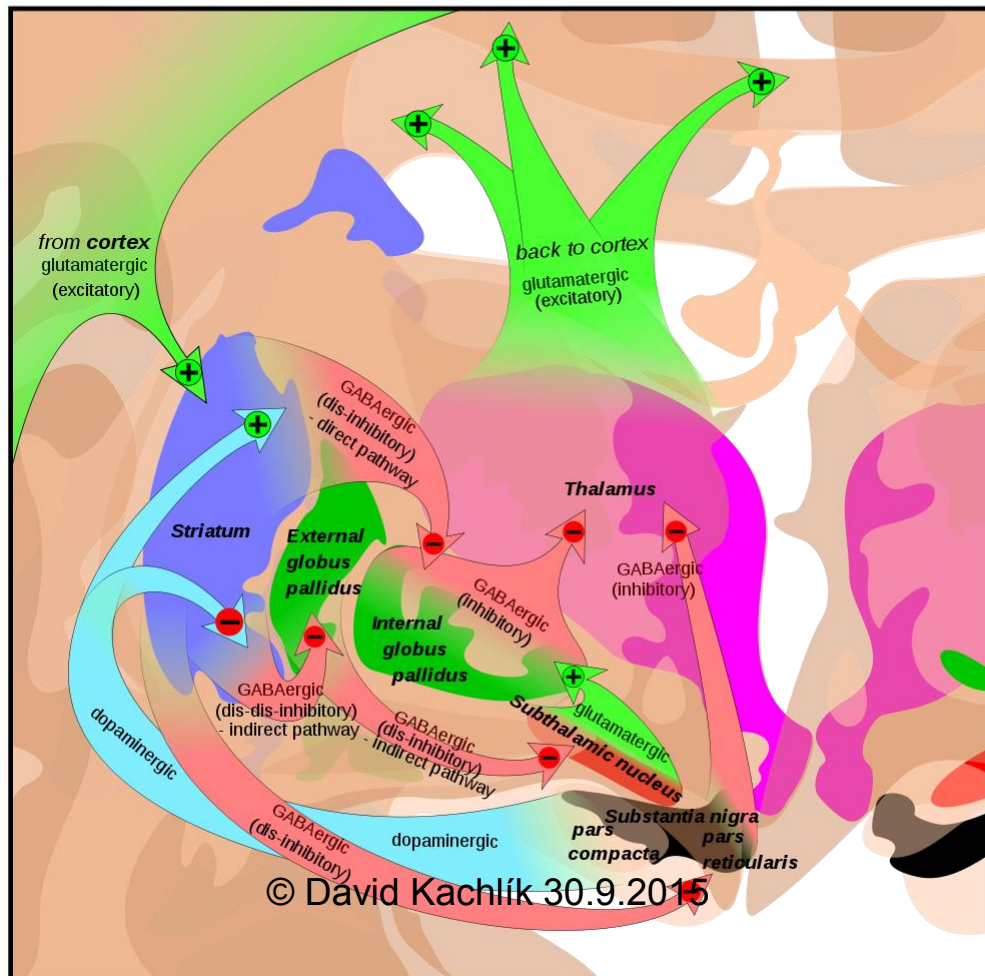
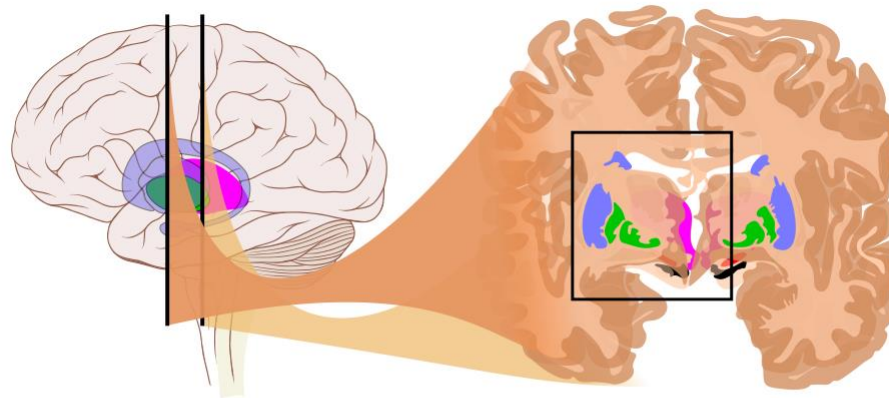


# Function of motor circuit: differs in quiet and in movement

## During movement (motorics activation)

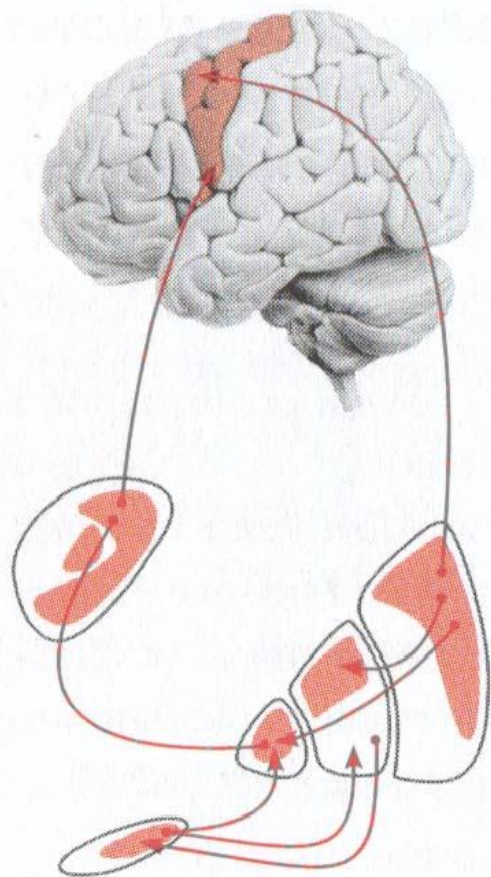
- During movement are activated **excitatory connections to BG** and consecutively **thalamus is involved**
- Output nuclei of BG physiologically inhibit motor activity. Prior to movement procurement there is also involvement **of motor loop** indirectly via **ncl. subthalamic Luysi**.
- → nucleus is connected into „**indirect**“ **BG tract** → **indirect motor tract of BG is inhibitory**.
- indirect tract works as a „brake“ on direct tract (modulates desinhibition of thalamus stimulated by direct tract)

Bazal ganlgia participates in preparation, control, level of muscle tenstion and termination of motor pattern. Stimuli for movement initiation appear in cortex prior to motor circuits of BG.

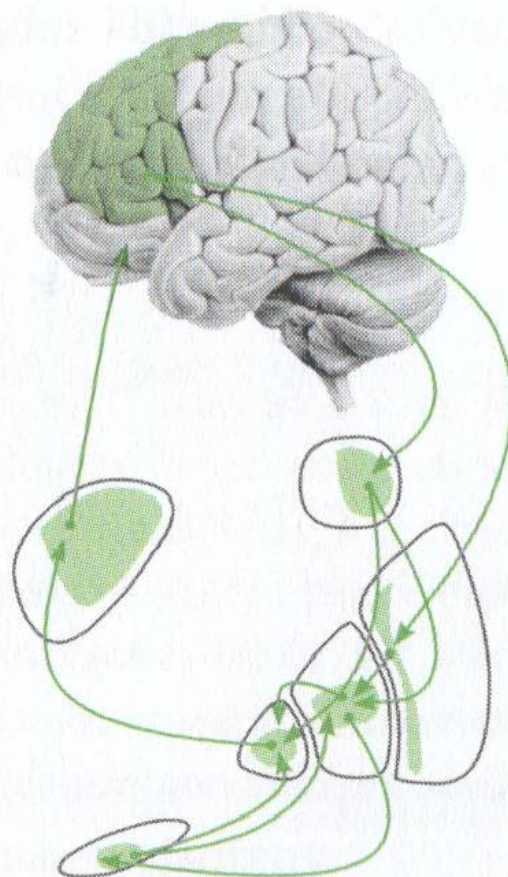


# Afferentation of BG

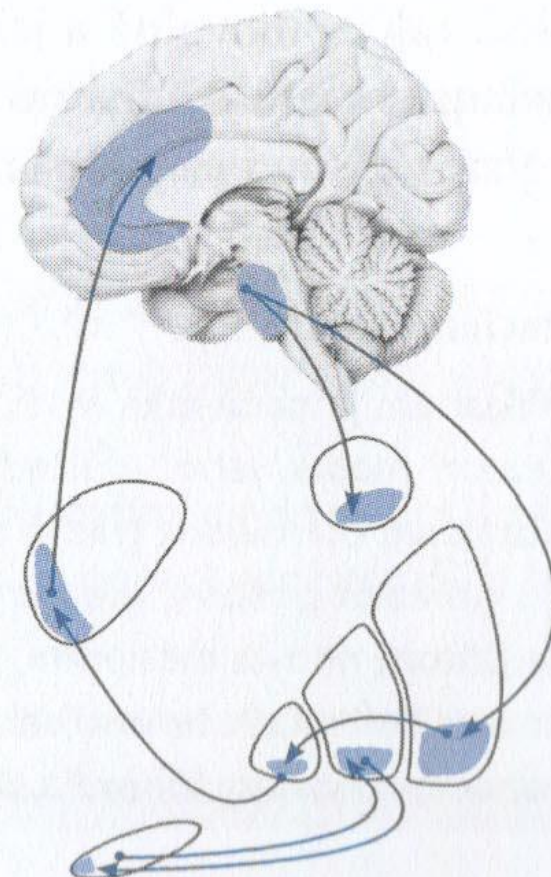
- cortex (mostly)
- pars compacta substantiae nigrae (→striatum) (*dopamin*)
- area ventralis tegmentalis Tsai (*dopamin*) (→striatum ventrale)
- ncll. intralaminares thalami (→striatum) – *fce nejasná*



motorický obvod



asociační obvod

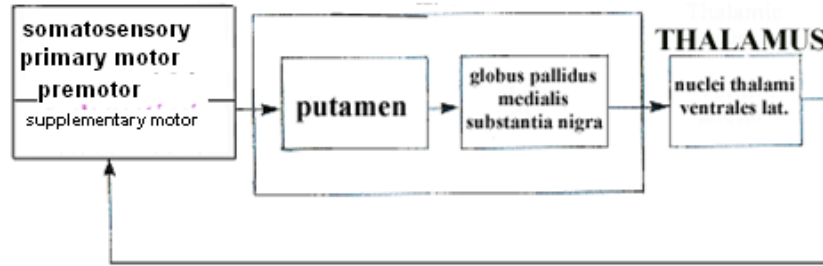


limbický obvod

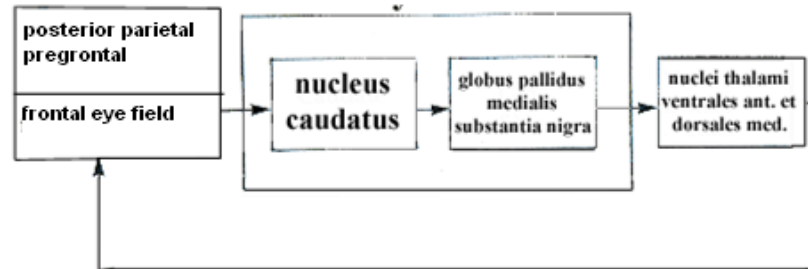
**Obr. 7.2.** Hlavní zapojení mozkové kůry a bazálních ganglií. Motorický obvod: BA 6 včetně SMA–BA 4–posterolaterální putamen–posterolaterální globus pallidus pars externa a pars interna–dorzo-laterální část nc. subthalamicus–ventrolaterální thalamus (podle: Obeso et al., 2006).

© David Kachlák 30.9.2015

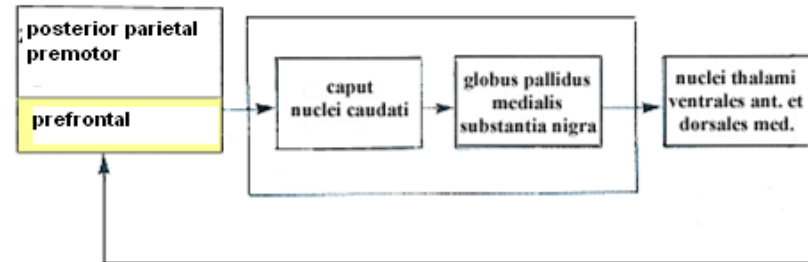
### sensorimotor loop



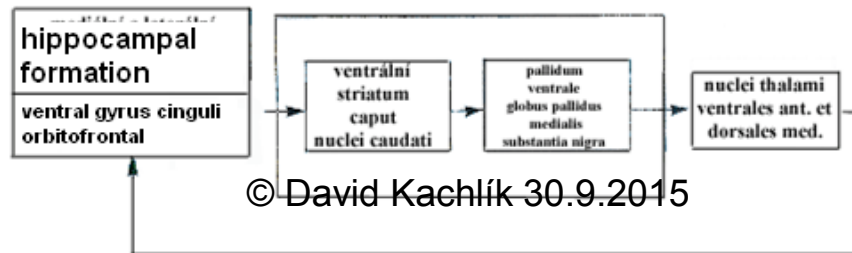
### Oculomotor loop

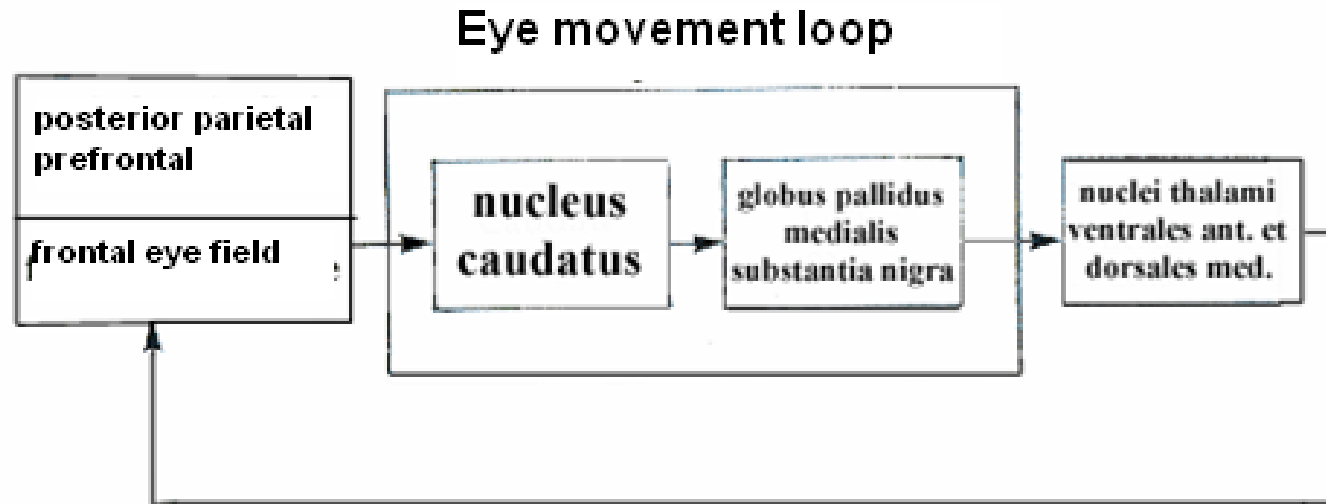


### Association loop

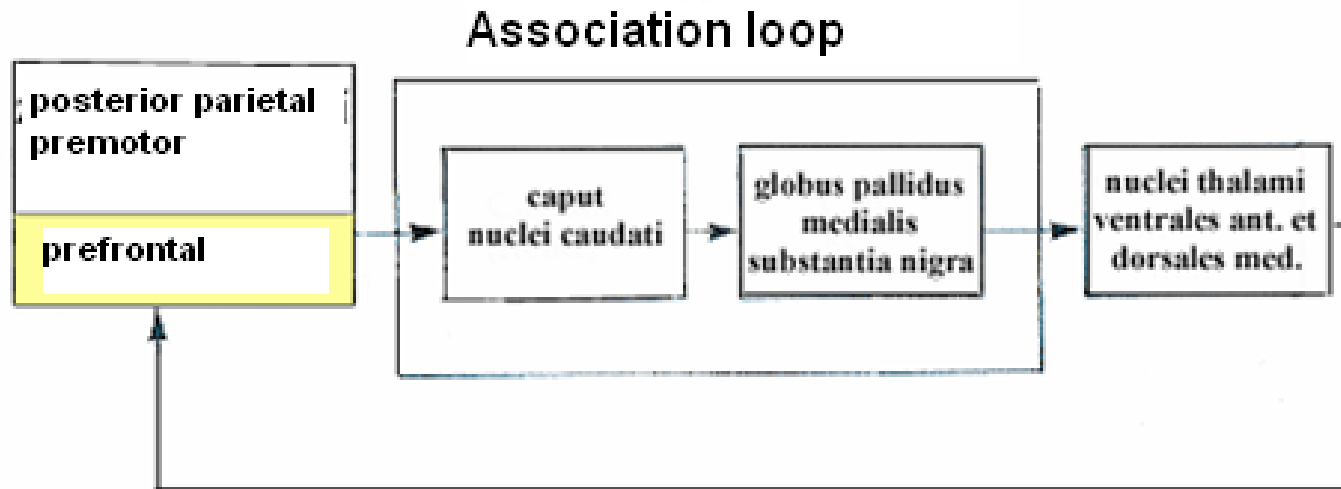


### Limbic loop



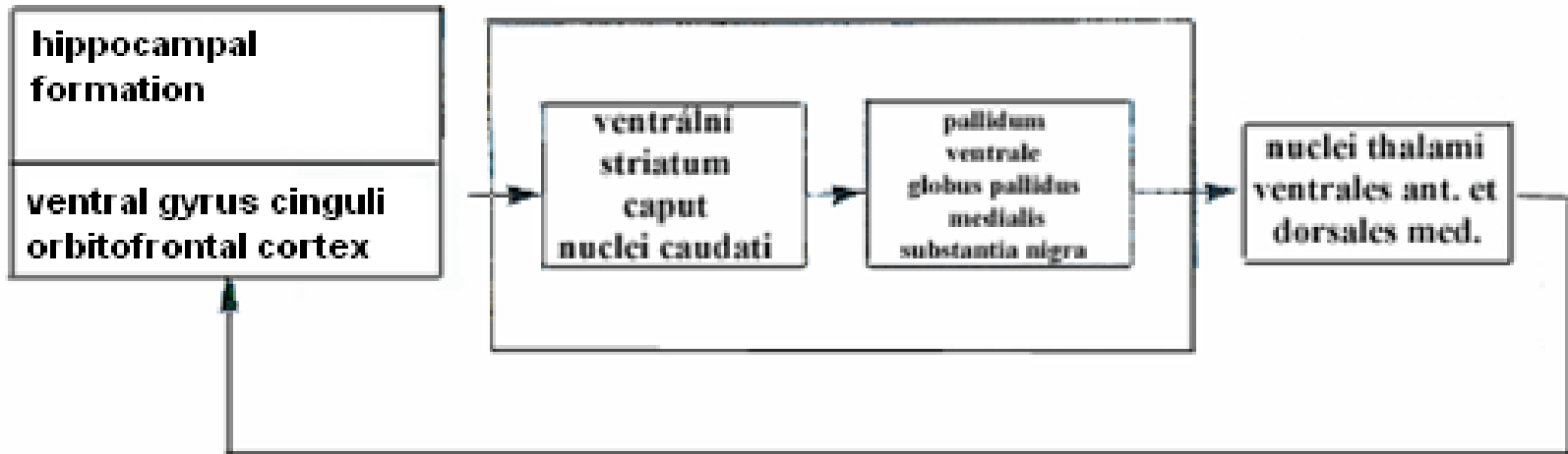


- Computation of eyes movement depending on visual inputs
- Connections from sb. nigra also into tectum and RF



- Spatial memory and evaluation of effectivity of motor behavior
- Connection to sb. nigra and tectum and RF

## Limbic loop



- Emotion expression by motorics and visceral reactions



# BAZAL GANGLIA (NUCLEI BASALES)

- **Substantia nigra Soemmeringi**
  - **pars compacta** - creates dopamin, enables activity of striatum
  - D1 receptors facilitate direct circuit of BG
  - D2 receptors inhibits indirect circuit of BG
  - **pars reticularis** - „relative“ of basal ganglia, connects influence of striatum to stem motorics (RF)
    - afferentation: striatum, ncl. subthalamicus
    - efferentation: thalamus, RF, colliculus superior

# BAZAL GANGLIA (NUCLEI BASALES)

- **nucleus subthalamicus (= corpus Luysi)**
  - Part of subthalamus
  - motor circuit of BG stimulates cortex
  - NSt stimulates GPM, that inhibits Th
  - Indirect circuit via NSt (inhibition of NSt) stimulates cortex
  
  - *lesion: hemiballismus (rough non coordinated movements of cingular muscles)*

# BAZAL GANGLIA (NUCLEI BASALES)

- **Corpus amygdaloidum (= amygdala = nucleus amgydalaе) = archistriatum**
  - Morphologically and developmentally belongs to basal ganglia
  - functionally and connectionally is part of **limbic system**
  - Is located in temporal lobe prior to cornu inferius of lateral ventricel and prior to cauda ncl. caudati and sometimes forms hippocampo-amygdaloid continuum
  - Complex of nuclei
  - If bilateral lesion → disappearance of aggresivity

# BAZAL GANGLIA (NUCLEI BASALES)

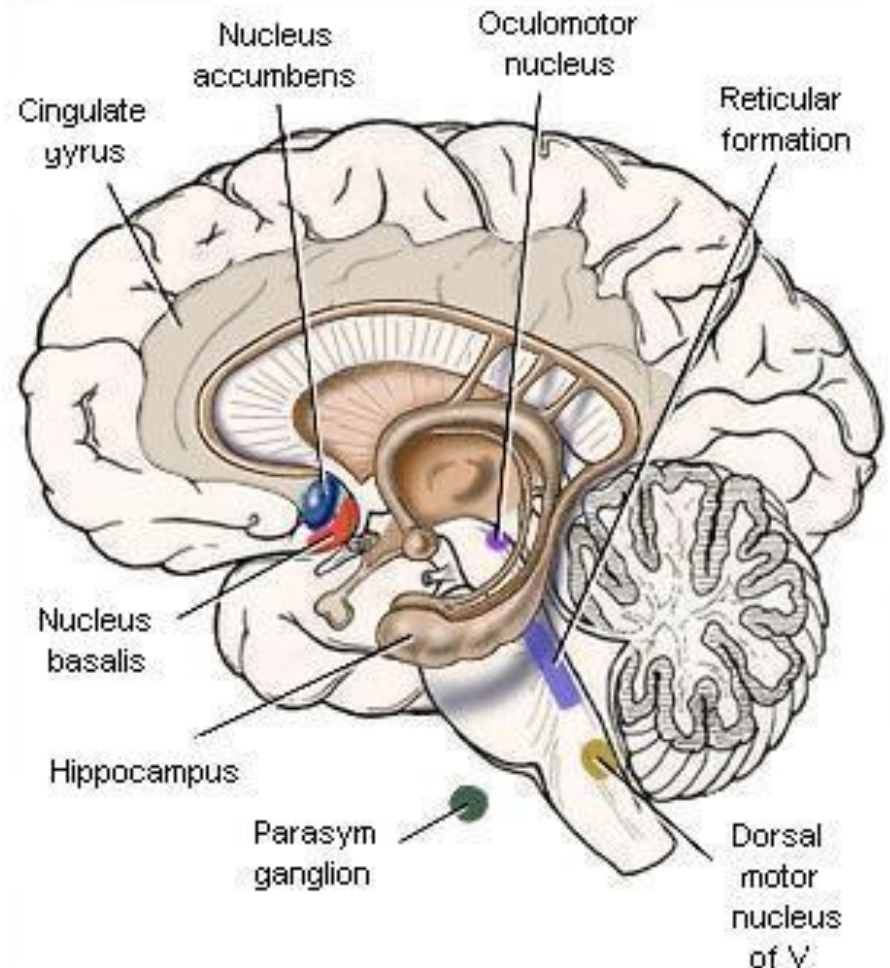
nucleus basalis

*Meynerti*

Disseminated groups of cholinergic neurons

Source of *acetylcholinu* for cortex

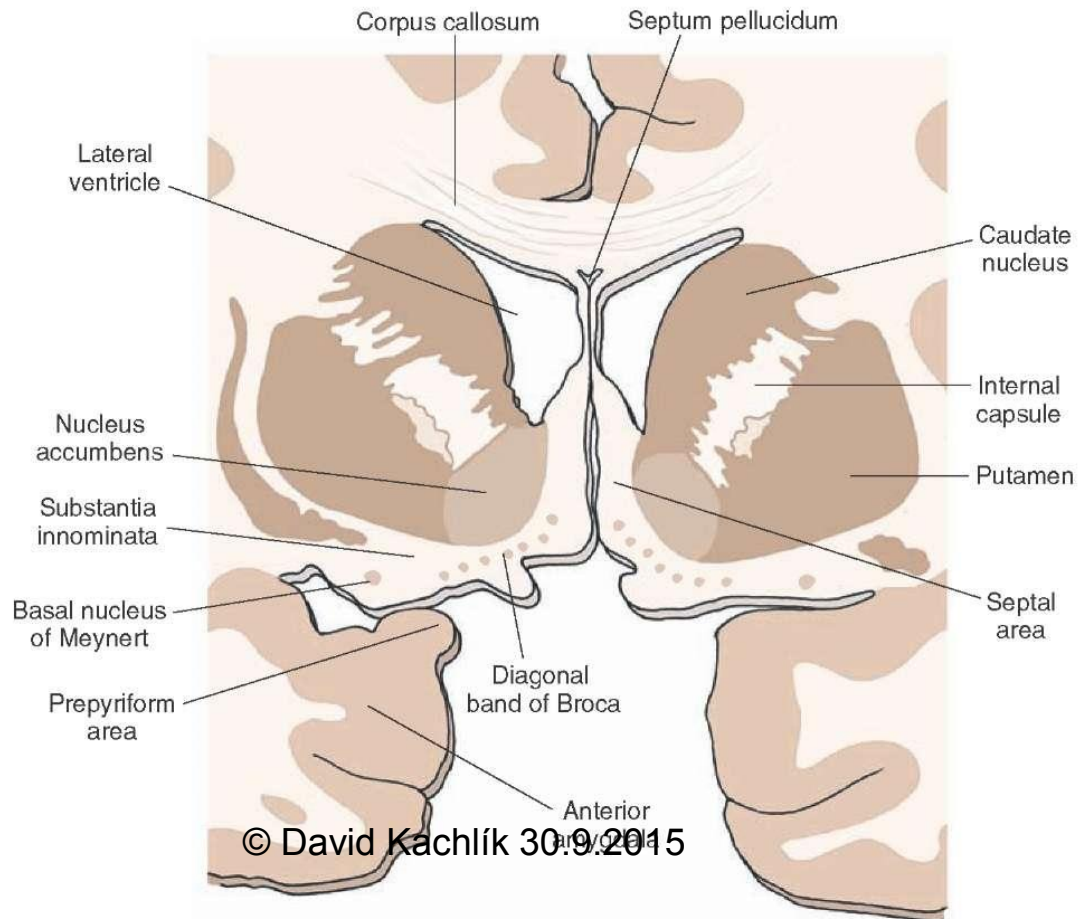
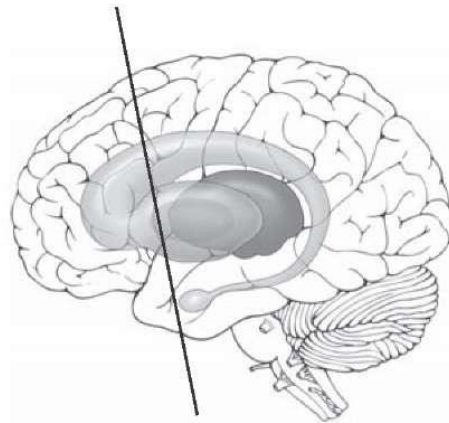
*morbus Alzheimer* →  
loss of Ach activity  
and degeneration of  
neurons in cortex



# BAZAL GANGLIA (NUCLEI BASALES)

- **nucleus accumbens**
- striatum ventrale
- Leaning on septum verum and is connected into limbic system
- Getting dopamin by mesolimbic path from ncl. subbrachialis (Tsai)
- Important role in addiction, reward, fear or placebo effect
- Nucleus of attachment and passion
- Reward center

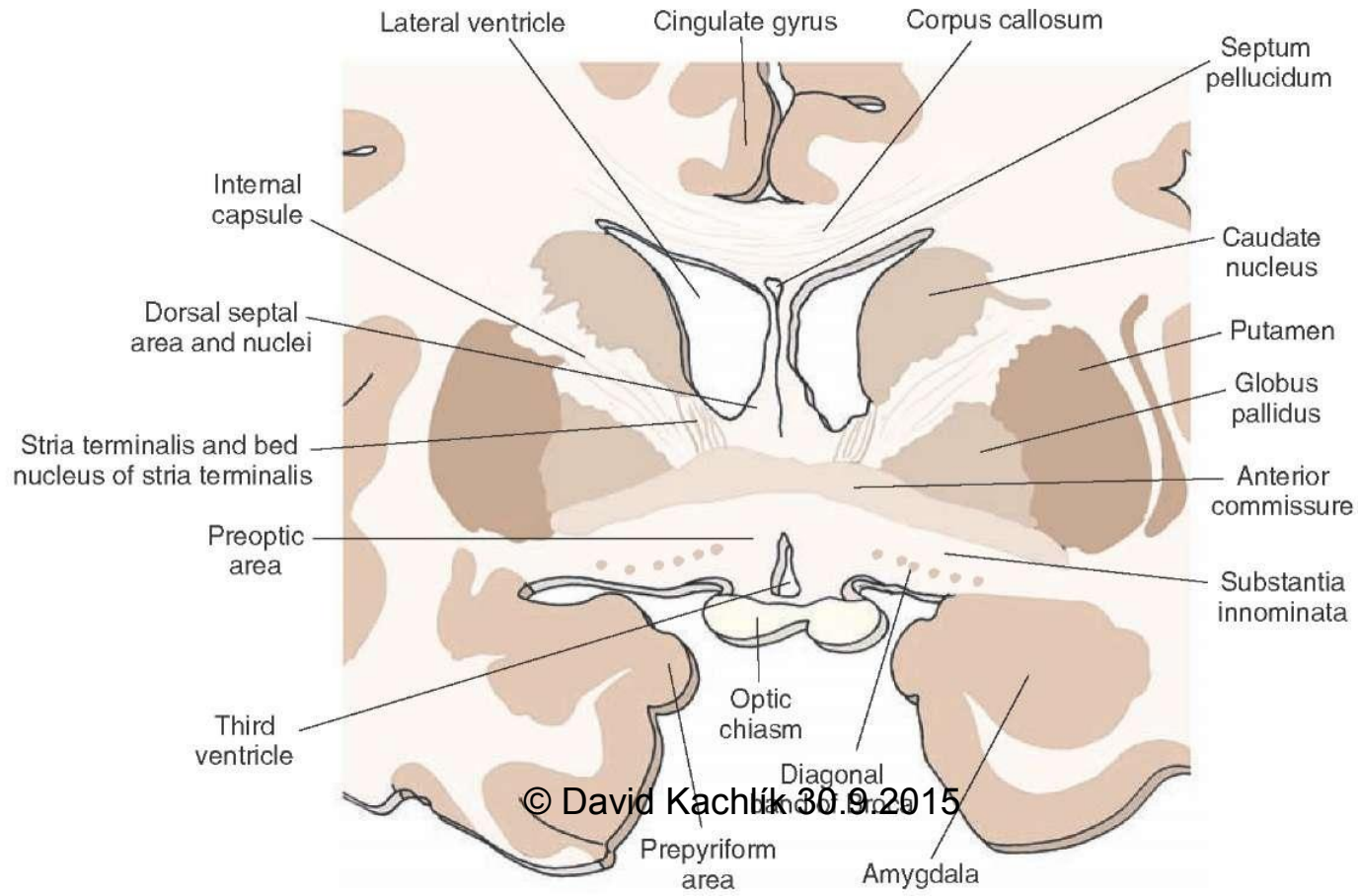
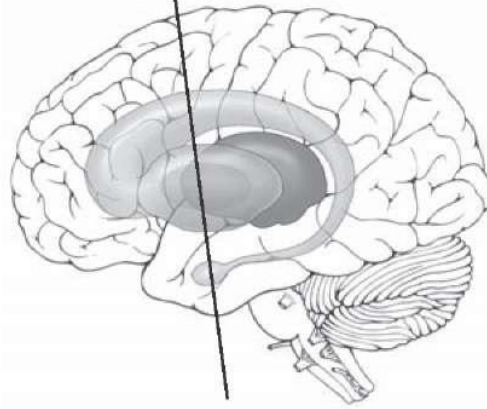
Level of section



# BAZAL GANGLIA (NUCLEI BASALES)

- *Substantia innominata Reicherti*  
= group of neurons ventrobazally to commissura anterior to the surface of hemispherium
  - striatum ventrale
  - pallidum ventrale
  - rostral part of nuclei from corpus amygdaloideum (medial and central)
    - nucleus basalis Meynerti (= scattered groups of cholinergic neurons) – source of *acetylcholinu*

Level of section



© David Kachlik 30.9.2015



# BAZAL GANGLIA (NUCLEI BASALES)

- **Clastrum**

- Sagittal plate laterally to ncl. lentiformis, medially to insula, basally to olfactory cortex
- Is not connected with other basal ganglia, but only with cortex!
- Function – **not clear, synesthesia**

# White matter in pars basilaris

- **Capsula interna**

- Between thalamus + nucleus caudatus (medially) and nucleus lentiformis (laterally)
- crus anterior, genu, crus posterior

- **Capsula externa**

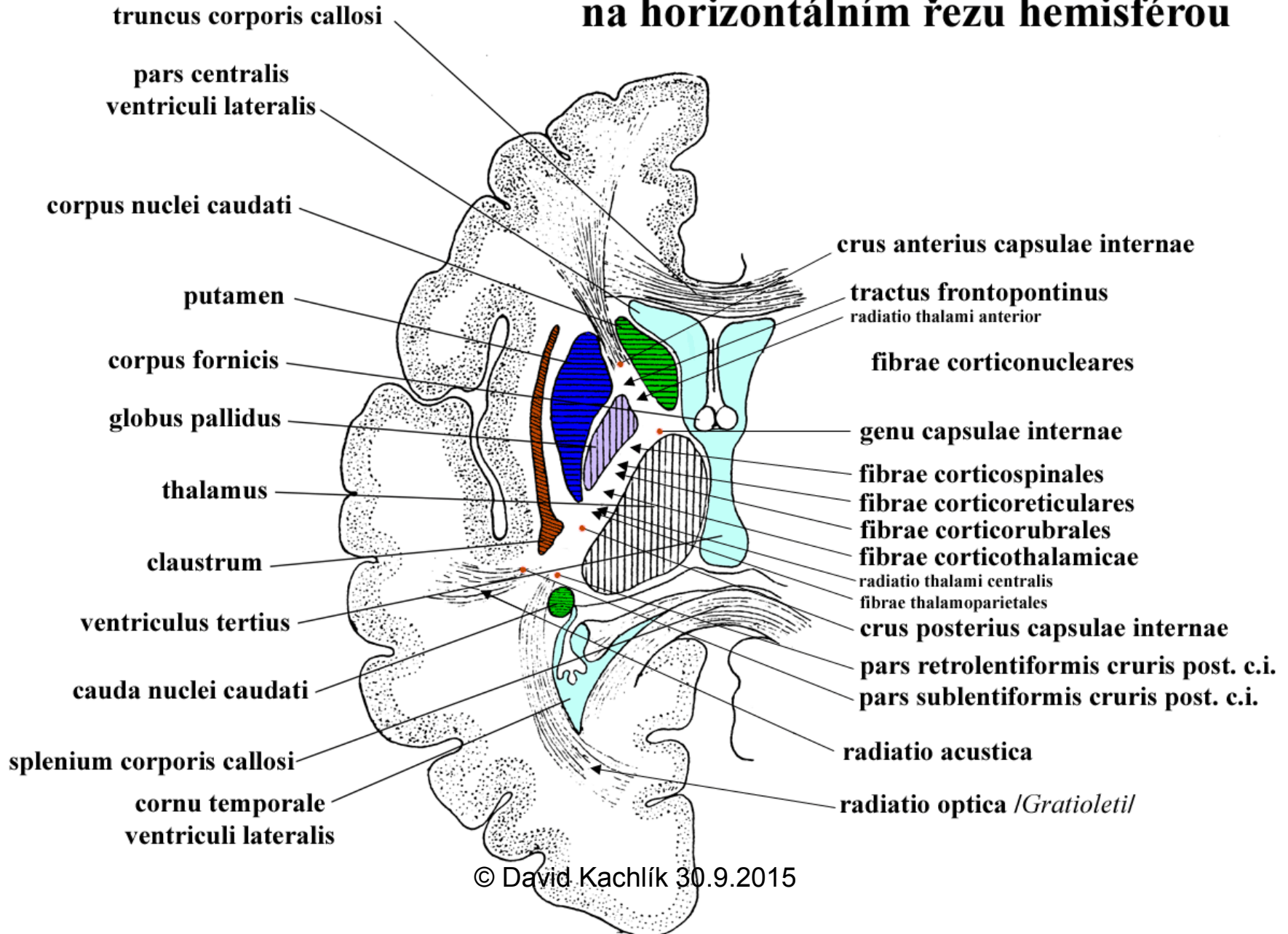
- Between nucleus lentiformis (medially) and claustrum (laterally)

- **Capsula extrema**

- between claustrum (medially) and cortex of insula (laterally)

# CAPSULA INTERNA

## na horizontálním řezu hemisférou



# ***Functional things BG***

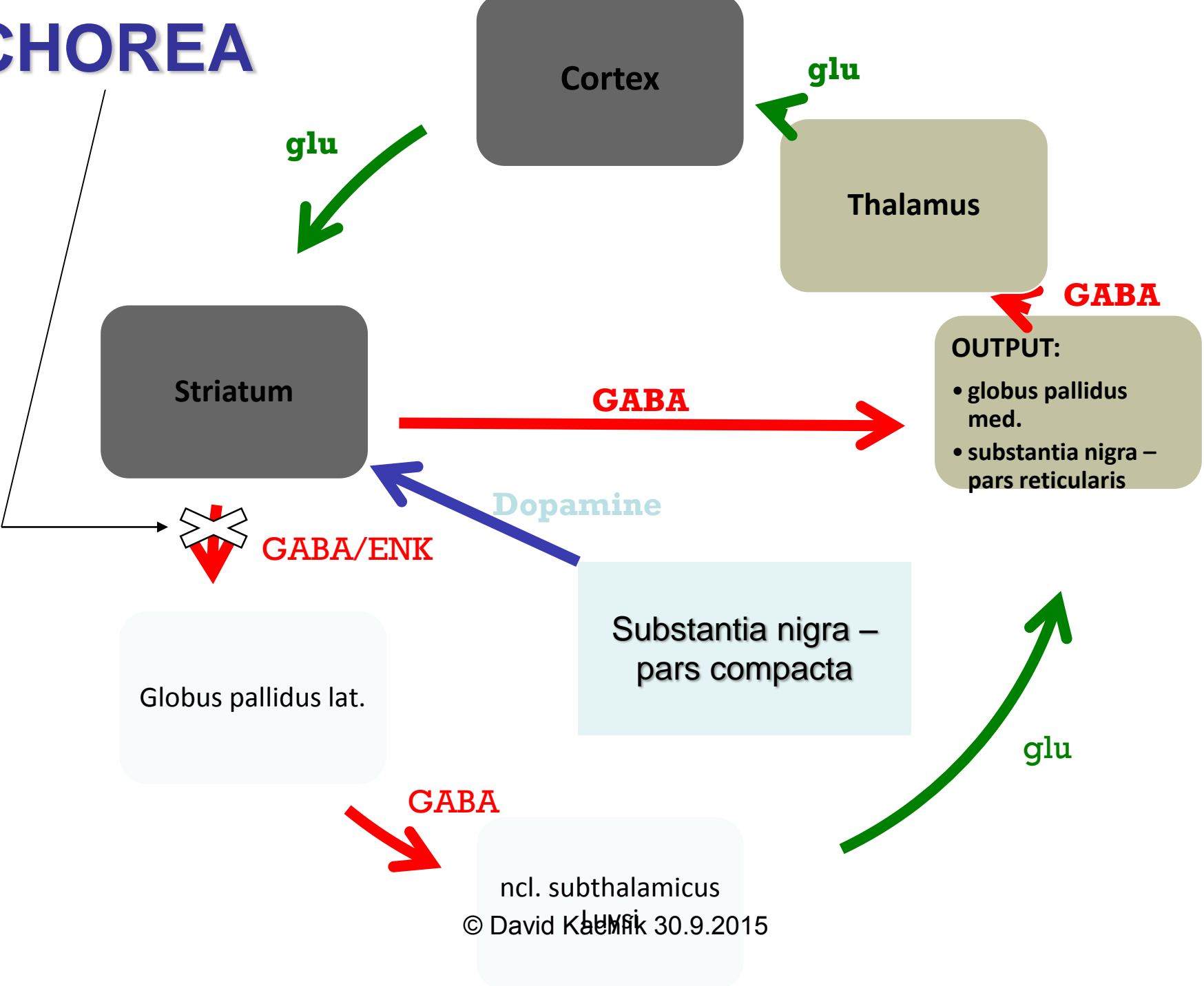
## **Selection of preprogrammed (learned) motor plans and patterns**

- *BG circuit= mechanism of selection of suitable pattern*
- Inability to select → *akinesia, hypokinesia*
- Wrong selection → *hyperkinesia*

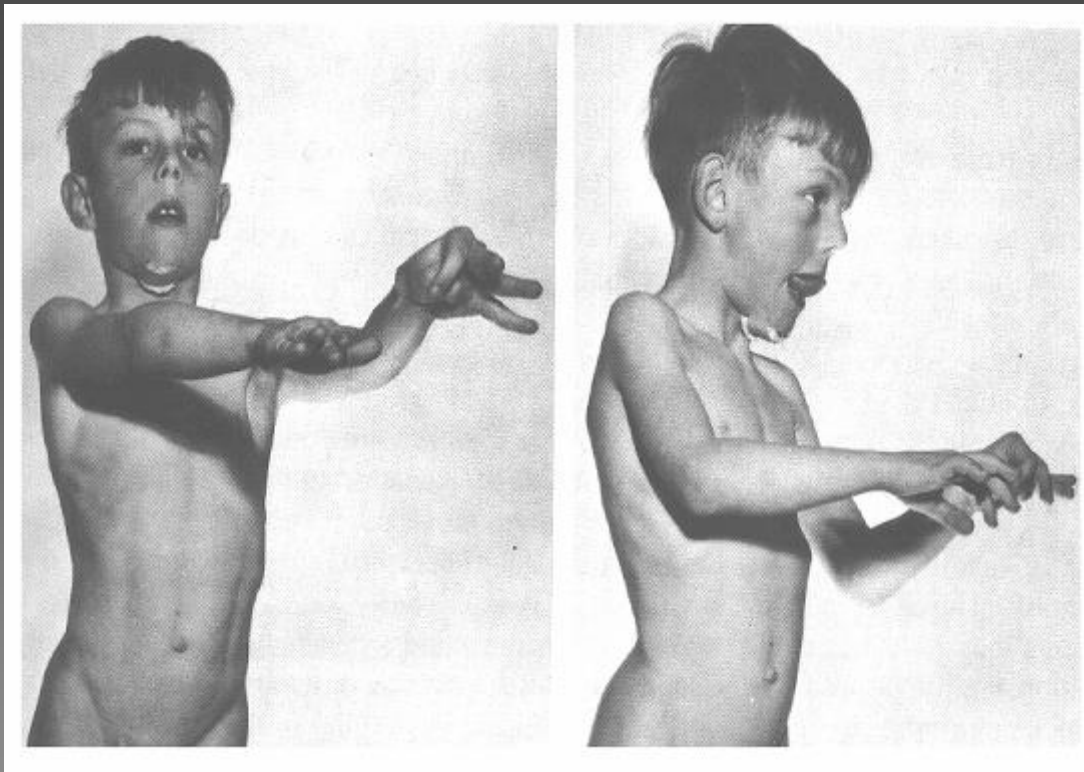
## **Generating (learning) motor patterns**

- Programming from several motor fragments into whole by routine movement stereotypes
- *Cerebral palsy* – defect of motor program

# CHOREA



# SYDENHAM'S CHOREA



*Principal Pathologic Lesion: Corpus Striatum*

## *Clinical Feature*

- **Complication of Rheumatic Fever**
- **Fine, disorganized, and random movements of extremities, face and tongue**
- **Accompanied by Muscular Hypotonia**
- **Typical exaggeration of associated movements during voluntary activity**
- **Usually recovers spontaneously in 1 to 4 months**

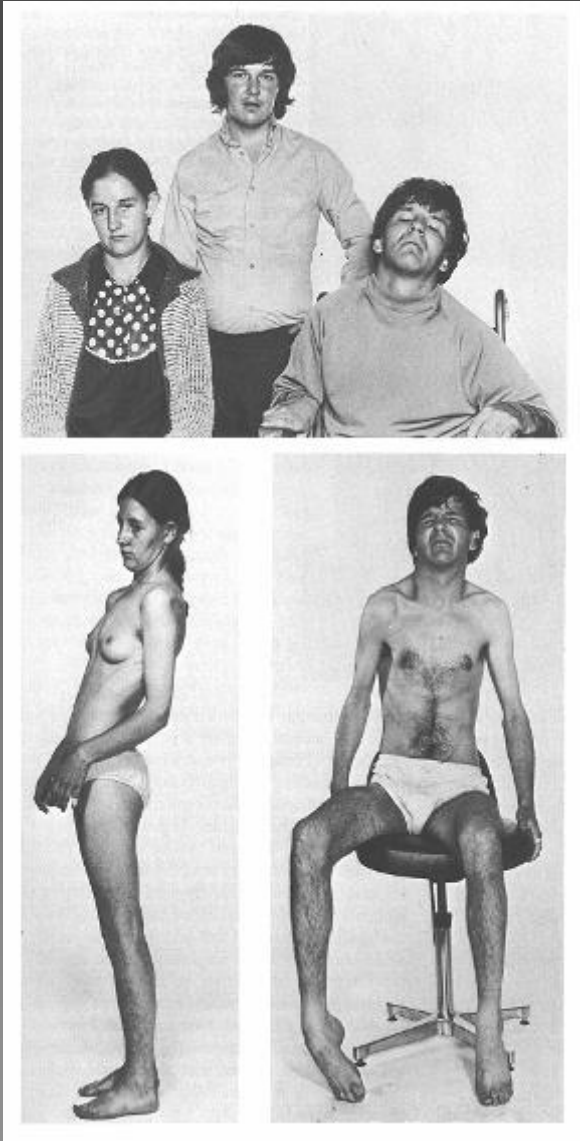
# HUNTINGTON'S CHOREA

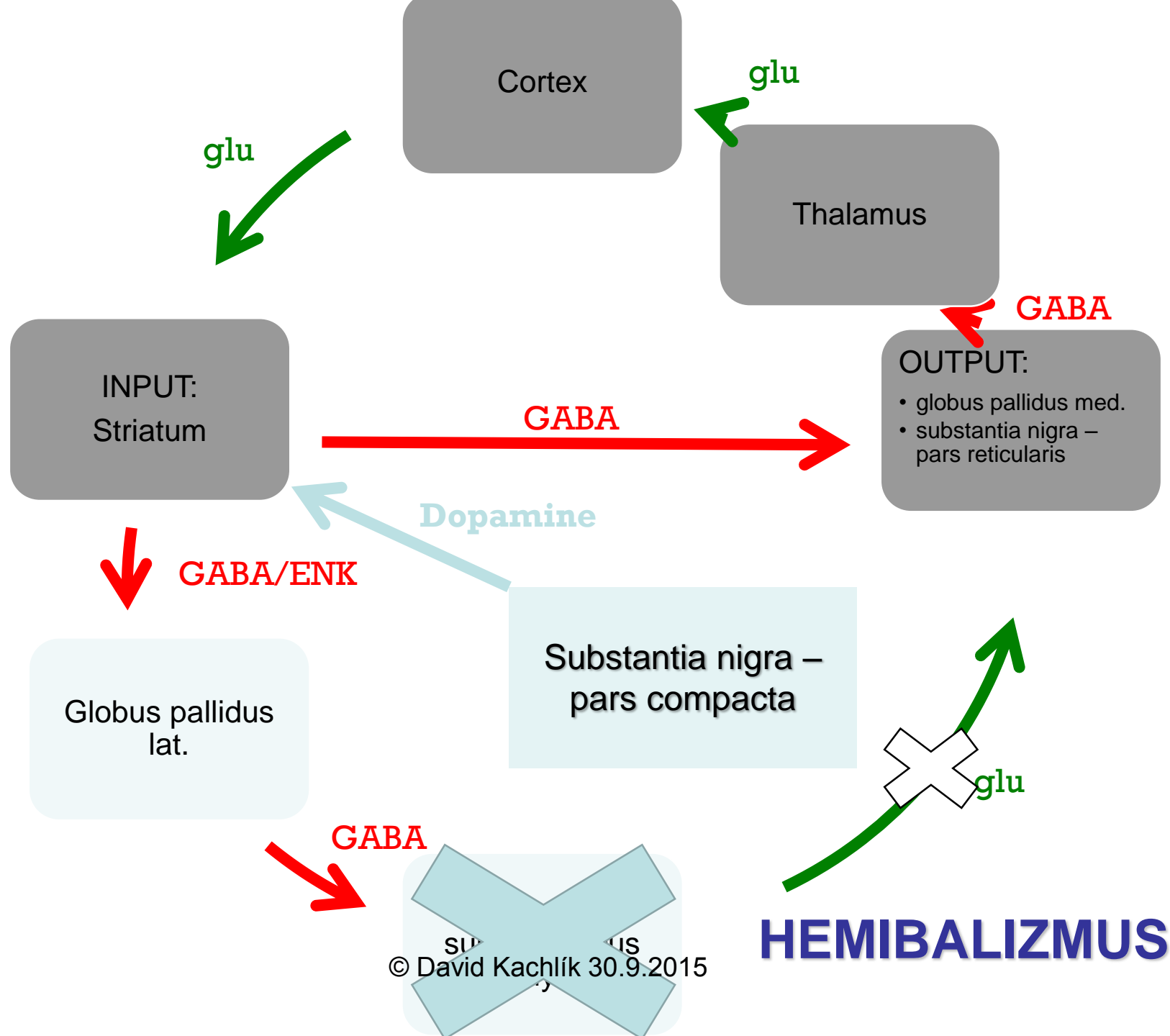
## Clinical Feature

- Predominantly **autosomal dominantly** inherited chronic fatal disease (Gene: chromosome 4)
- **Insidious onset: Usually 40-50**
- **Choreic movements in onset**
- **Frequently associated with emotional disturbances**
- **Ultimately, grotesque gait and sever dysarthria, progressive dementia ensues.**

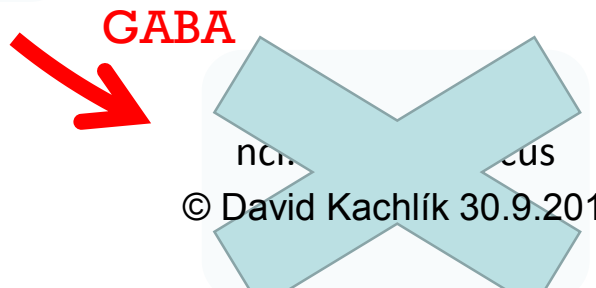
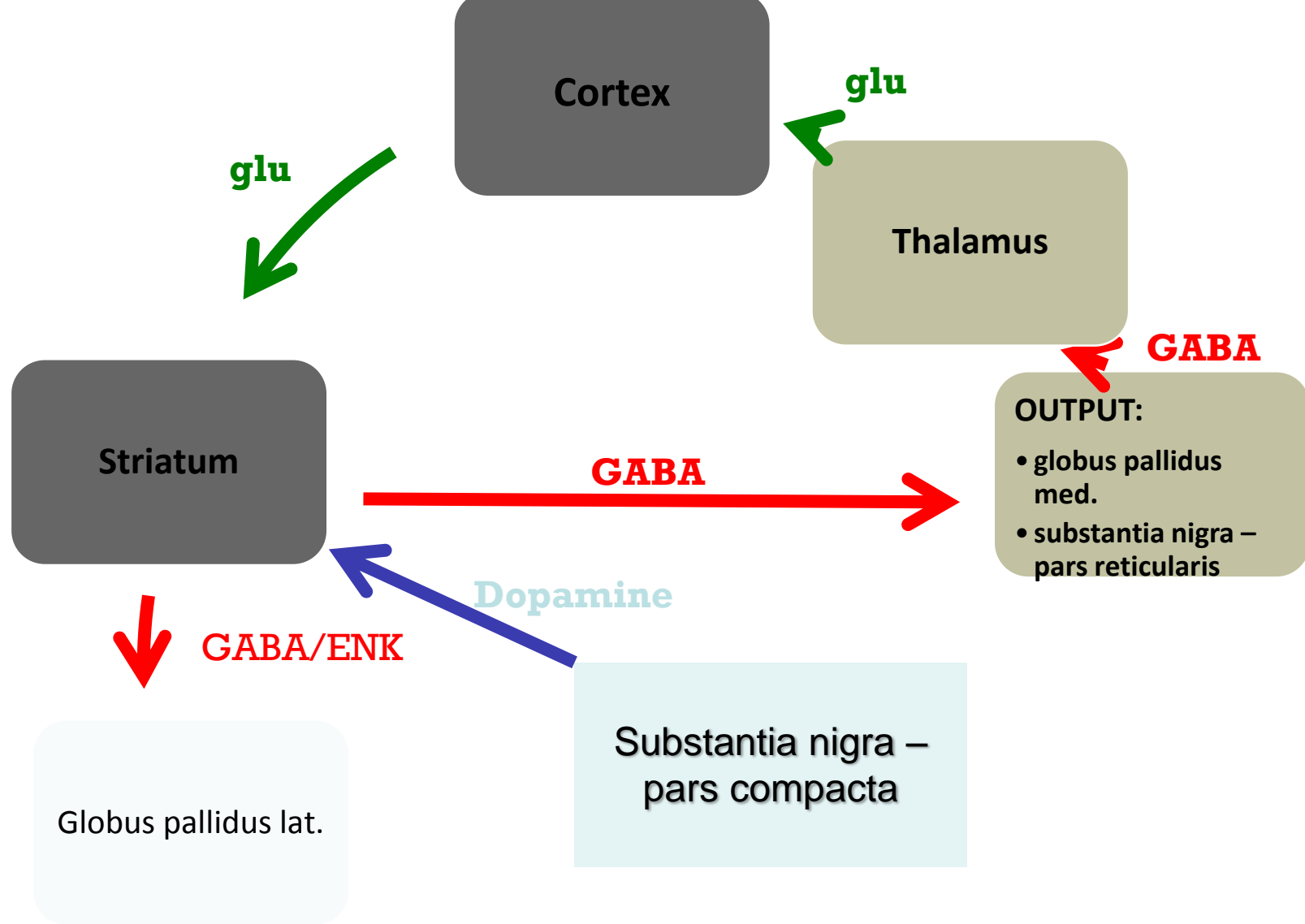
## *Principal Pathologic Lesion:*

*Corpus Striatum (esp. caudate nucleus)  
and Cerebral Cortex*









# HEMIBALIZMUS

# HEMIBALLISM



## Clinical Feature

- Usually results from CVA (Cerebrovascular Accident) involving subthalamic nucleus
- sudden onset
- Violent, writhing, involuntary movements of wide excursion confined to *one half of the body*
- The movements are continuous and often exhausting but cease during sleep
- Sometimes fatal due to exhaustion
- Could be controlled by phenothiazines and stereotaxic surgery

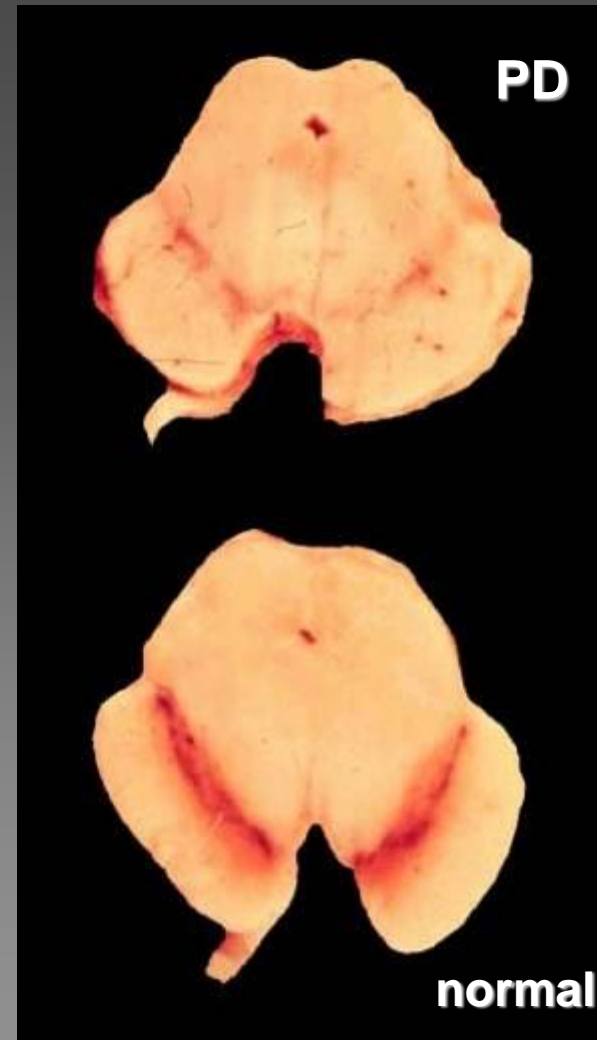
**Lesion: Subthalamic Nucleus**

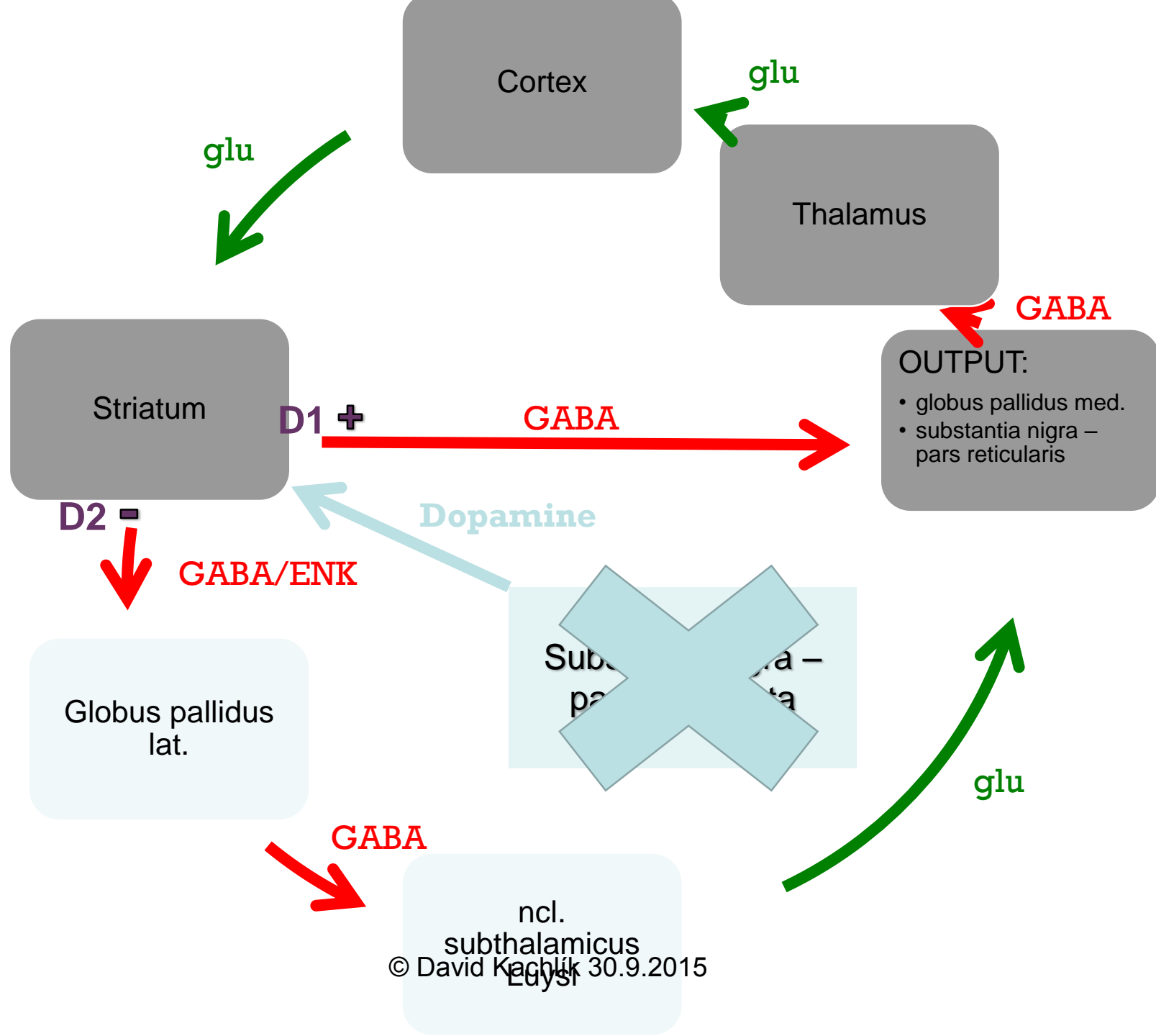
# ***Parkinson's Disease***

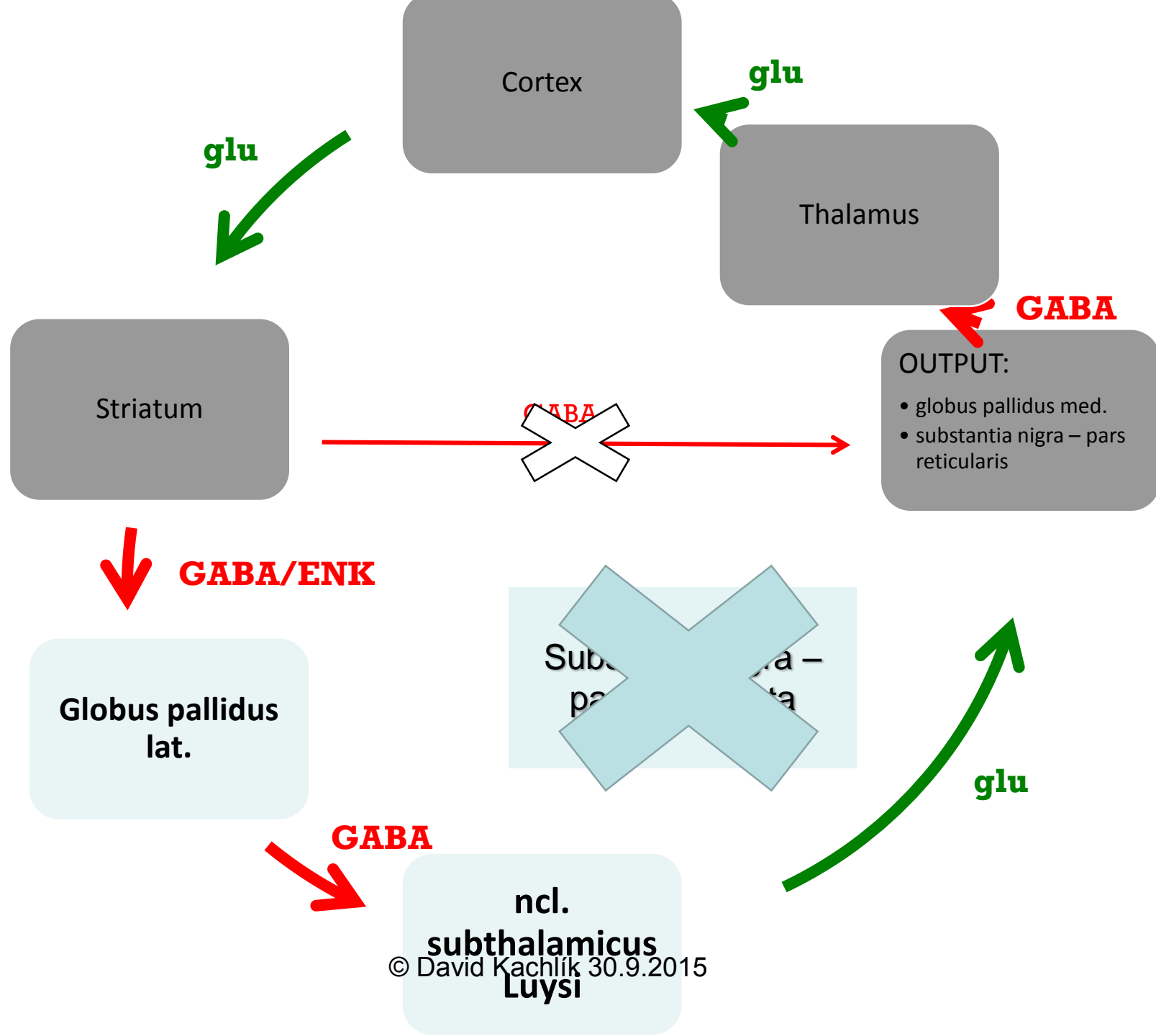
***Disease of mesostriatal  
dopaminergic system***



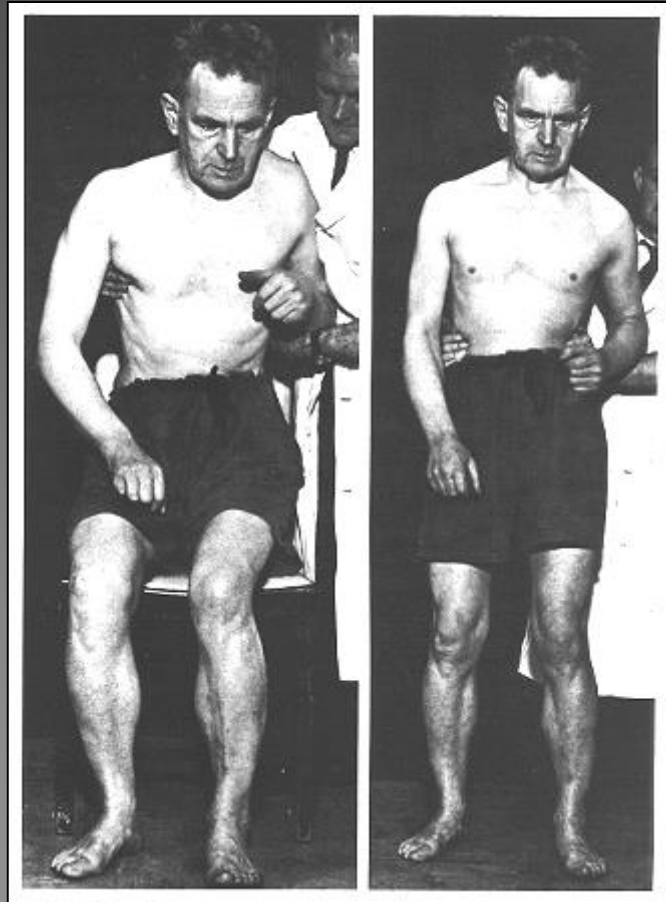
Muhammad Ali in Atlanta Olympic







# Parkinson's Disease - Paralysis Agitans



Substantia Nigra,  
Pars Compacta (SNc)  
DOPAMINERGIC Neuron

## Clinical Feature (1)

Slowness of Movement

**BRADYKINESIS**

- *Difficulty in Initiation and Cessation of Movement*



## ***Parkinson's Disease Paralysis Agitans***



### ***Clinical Feature (2)***

---

**Resting Tremor  
Parkinsonian Posture  
Rigidity-Cogwheel Rigidity**

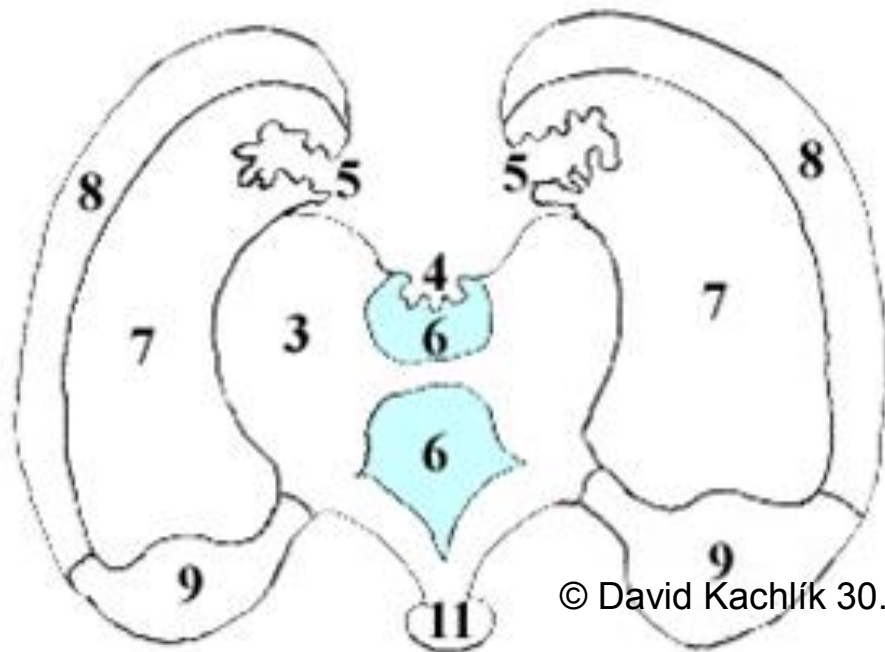
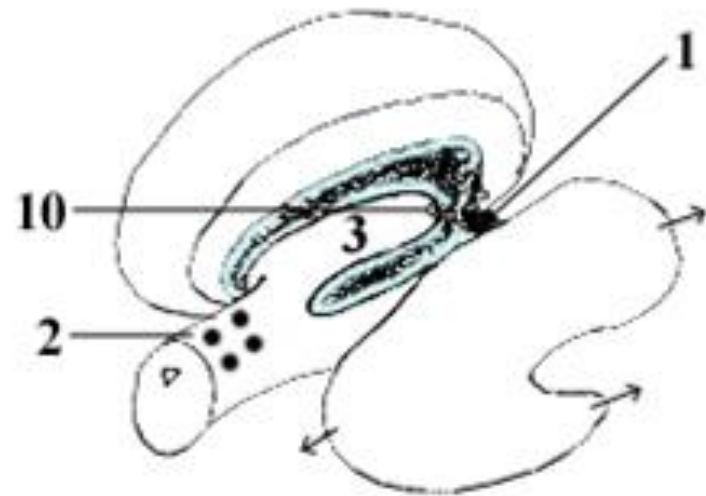
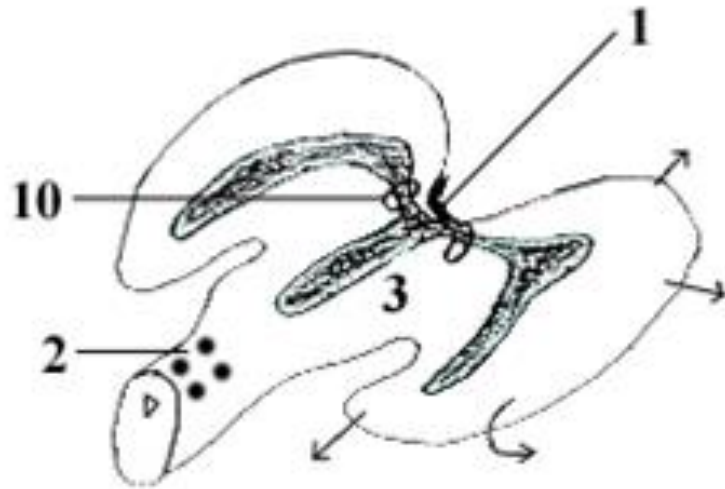
# PARS BASALIS TELEENCEPHALI

= new part includes structures already scattered in other parts, may contain structures also included into BG

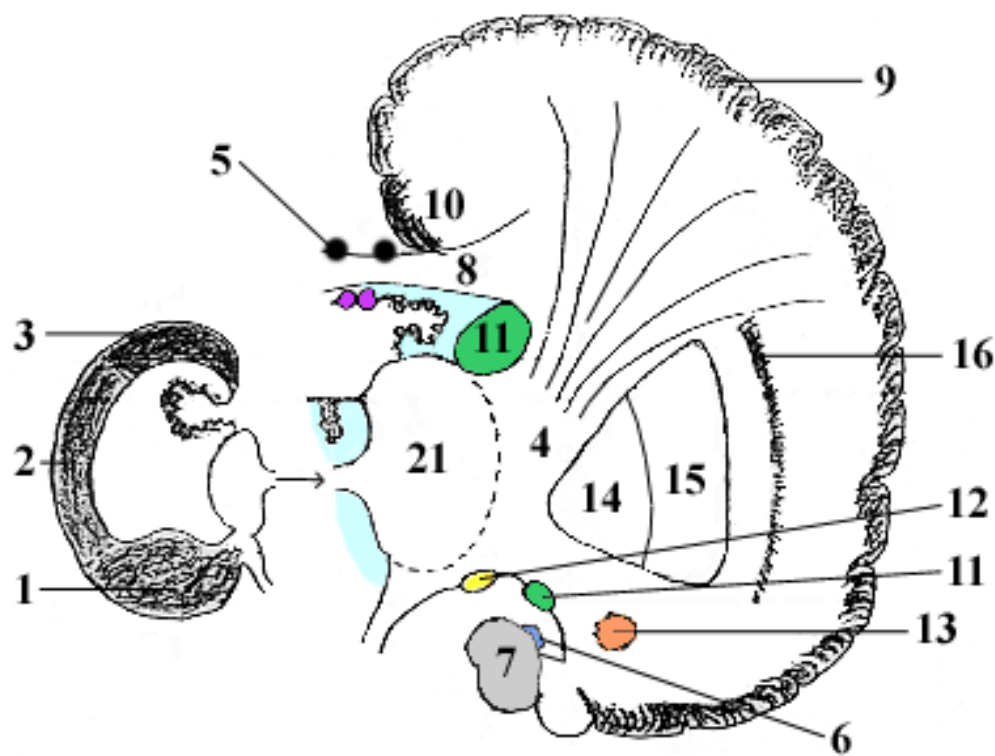
- corpus amygdaloideum – developmentally to BG, functionally to LS
- claustrum – developmentally to BG, functionally with motor cortex
- (stria diagonalis, subsantia basalis), substantia innomnata Reicherti
- Olfactory part: insulae olfactoriae, bulbus olfactorius (pedunculus, tractus, trigonum, tuberculum), striae olfactoriae med.+lat., substantia perforata anterior
- pallidum ventrale + striatum ventrale (+ nucleus accumbens)
- area septalis



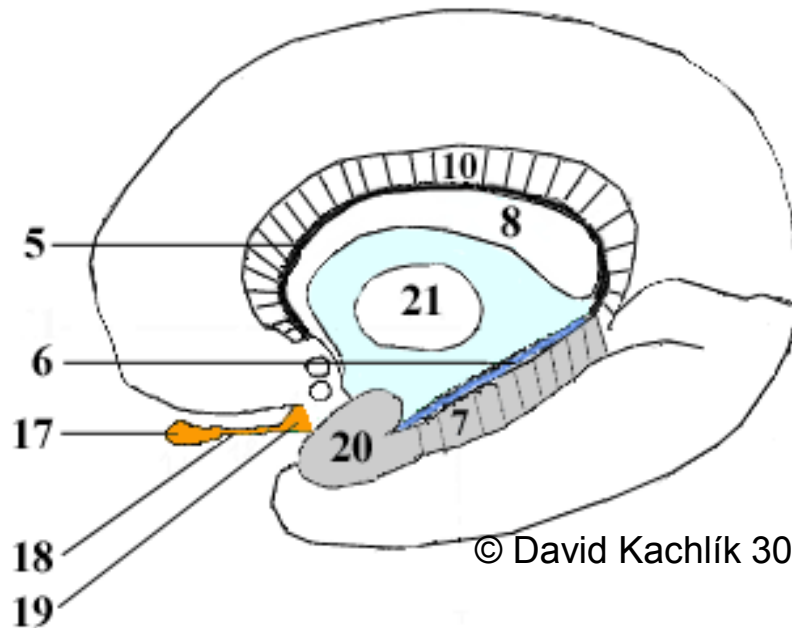
# TELENCEPHALON - development



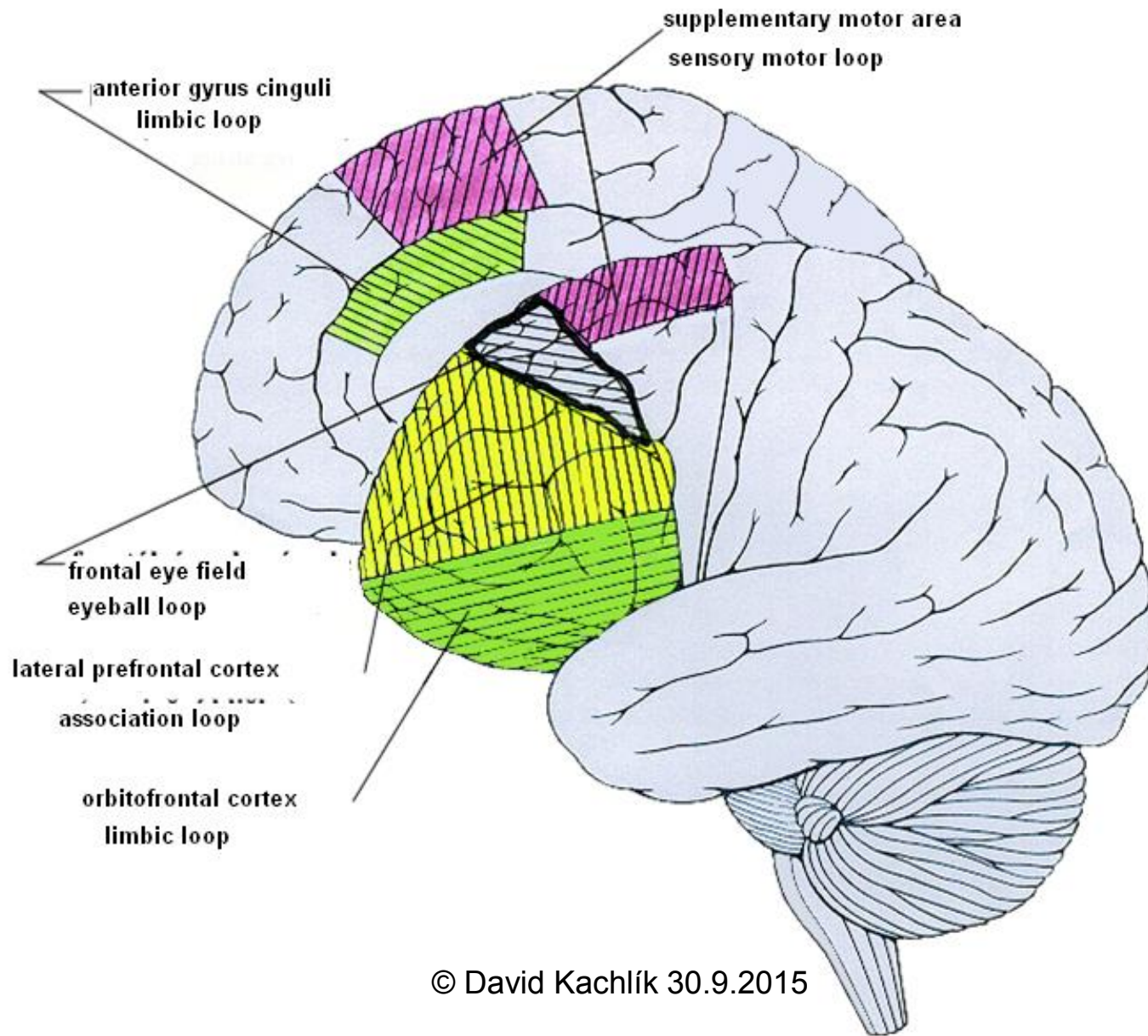
- 1 - lamina terminalis
- 2 - mesencephalon
- 3 - diencephalon
- 4 - strop III. komory
- 5 - mediální stěna laterální komory
- 6 - III. komora
- 7 - laterální komora
- 8 - pallium
- 9 - pars basilaris telencephali
- 10 - foramen interventriculare /Monroi/
- 11 - hypophysis (glandula pituitaria)



- 1 - archicortex
- 2 - paleocortex
- 3 - paleostriatum
- 4 - capsula interna
- 5 - striae longitudinales corporis callosi
- 6 - gyrus dentatus
- 7 - gyrus parahippocampalis
- 8 - corpus callosum
- 9 - neocortex
- 10 - gyrus cinguli
- 11 - nucleus caudatus
- 12 - tractus opticus
- 13 - corpus amygdaloideum (archistriatum)
- 14 - pallidum (paleostriatum)
- 15 - putamen (neostriatum)
- 16 - claustrum (neostriatum)
- 17 - bulbus olfactorius
- 18 - tractus olfactorius
- 19 - trigonum olfactorium
- 20 - uncus g. parahippocampalis
- 21 - thalamus



# Lateral and medial view of frontal and parietal cortex



# Basal ganglia and reward reaction

