NeuroAnatomie : Introduction

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2013 - 2014

Généralités

Traitement de l'information

Névraxe

- cerveau, Cervelet, tronc cérébral, moelle spinale

Echelle macroscopique et ima cérébrale

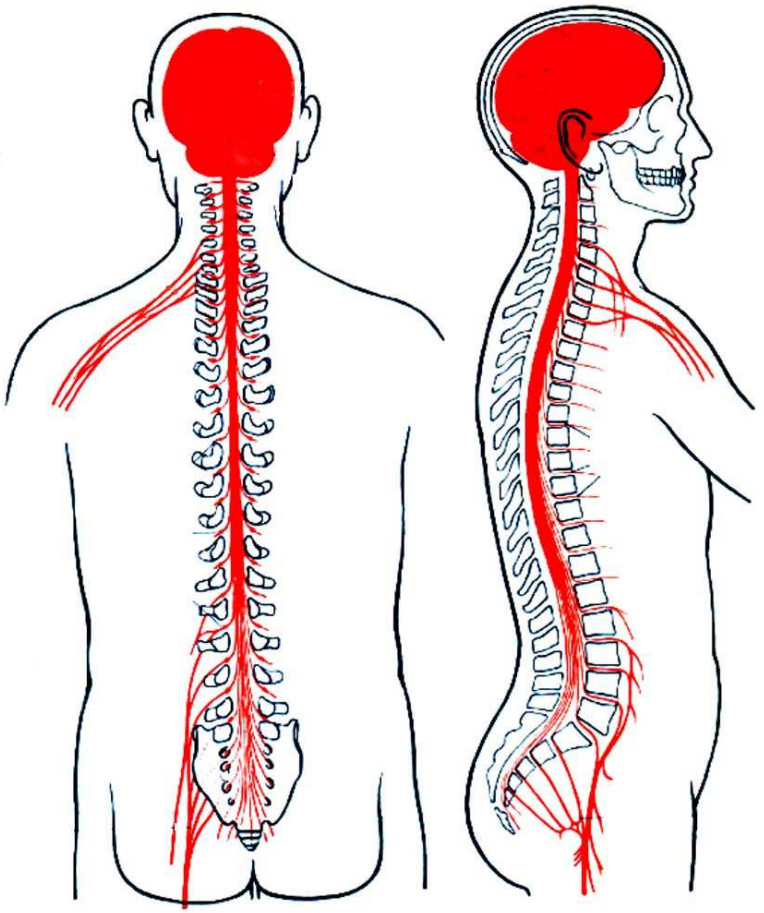
Echelle histologique : neurone cellules gliales, méninges.

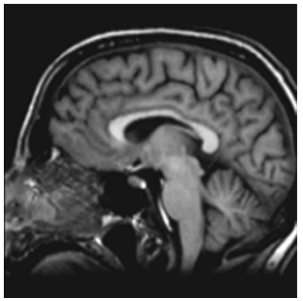
Neurobiochimie,

neurogénétique,

neurobiologie cellulaire ……

Circuit neuronaux





Plans et référentiels

Langage anatomique et nomenclature

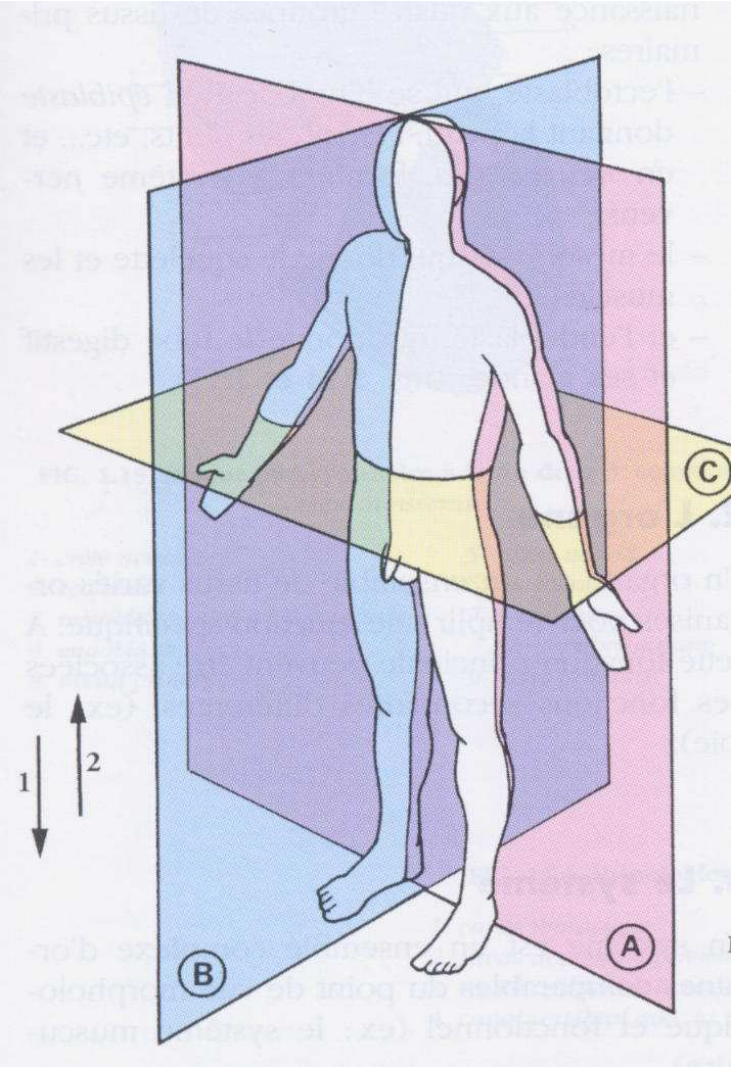
INTRODUCTION À L'ANATOMIE

Nomenclature

- 1895 Nomina Anatomica de Bâle (BNA)
- 1955 Nomina Anatomica de Paris (PNA).
- 1998 Terminologia Anatomica

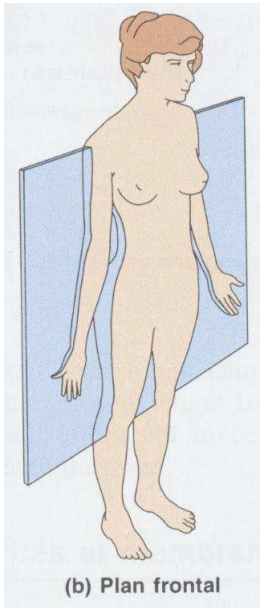
Nomenclature Ancienne	Nomenclature Moderne
Amygdale Nerf pathétique	Tonsille Nerf trochléaire

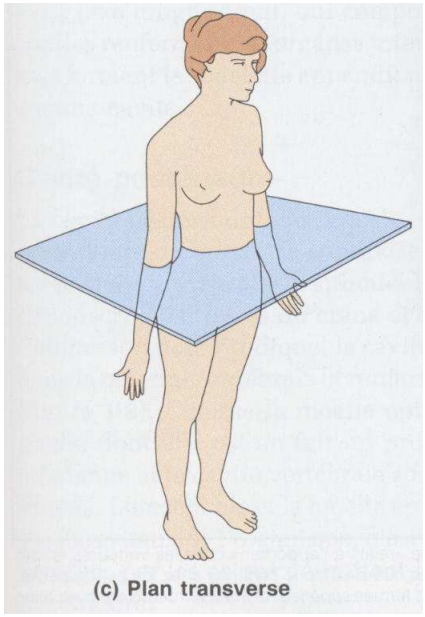
Position anatomique de base

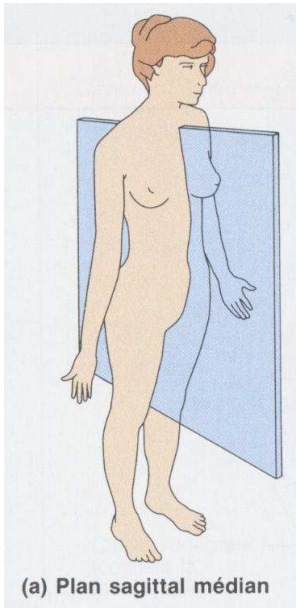


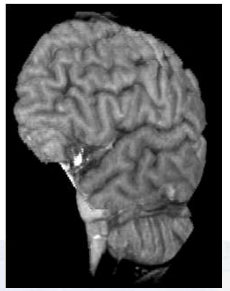
- Debout
- Paumes vers l ’avant
- Regard droit

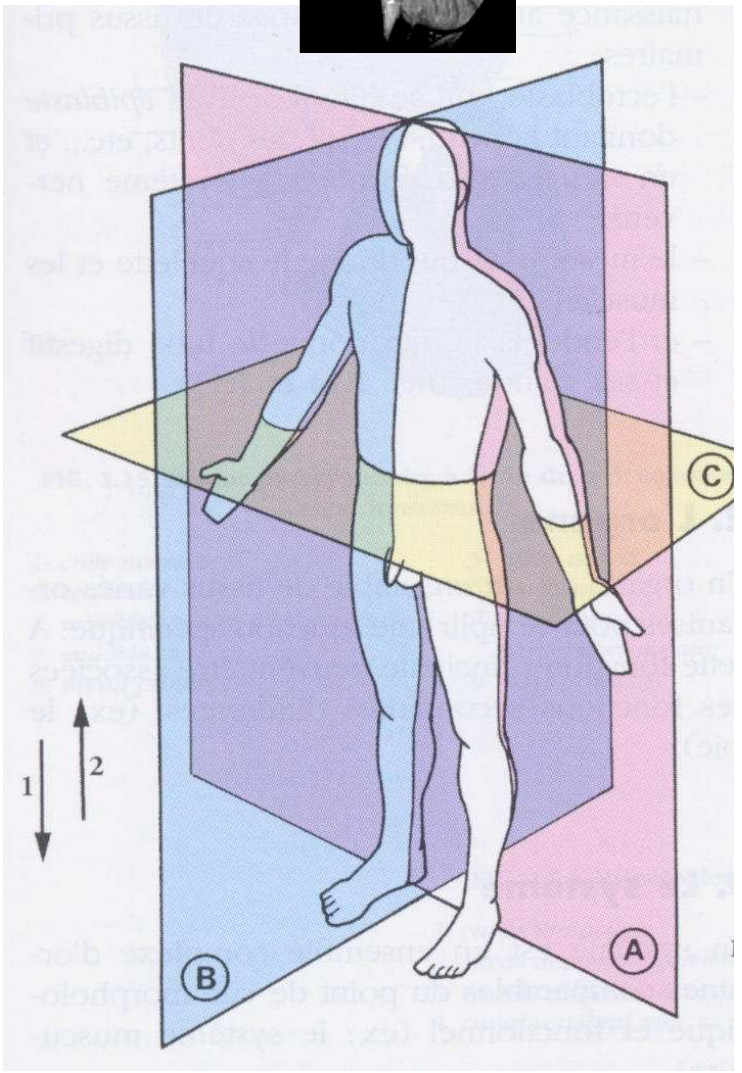
Plans de référence

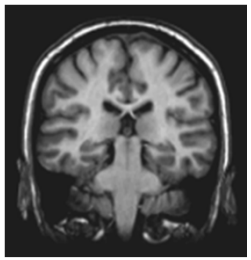

(b) Plan frontal

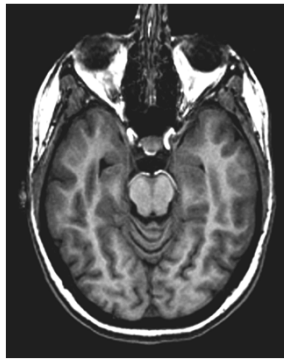

(c) Plan transverse

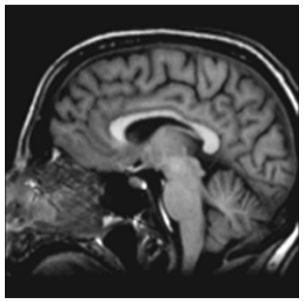

(a) Plan sagittal médian





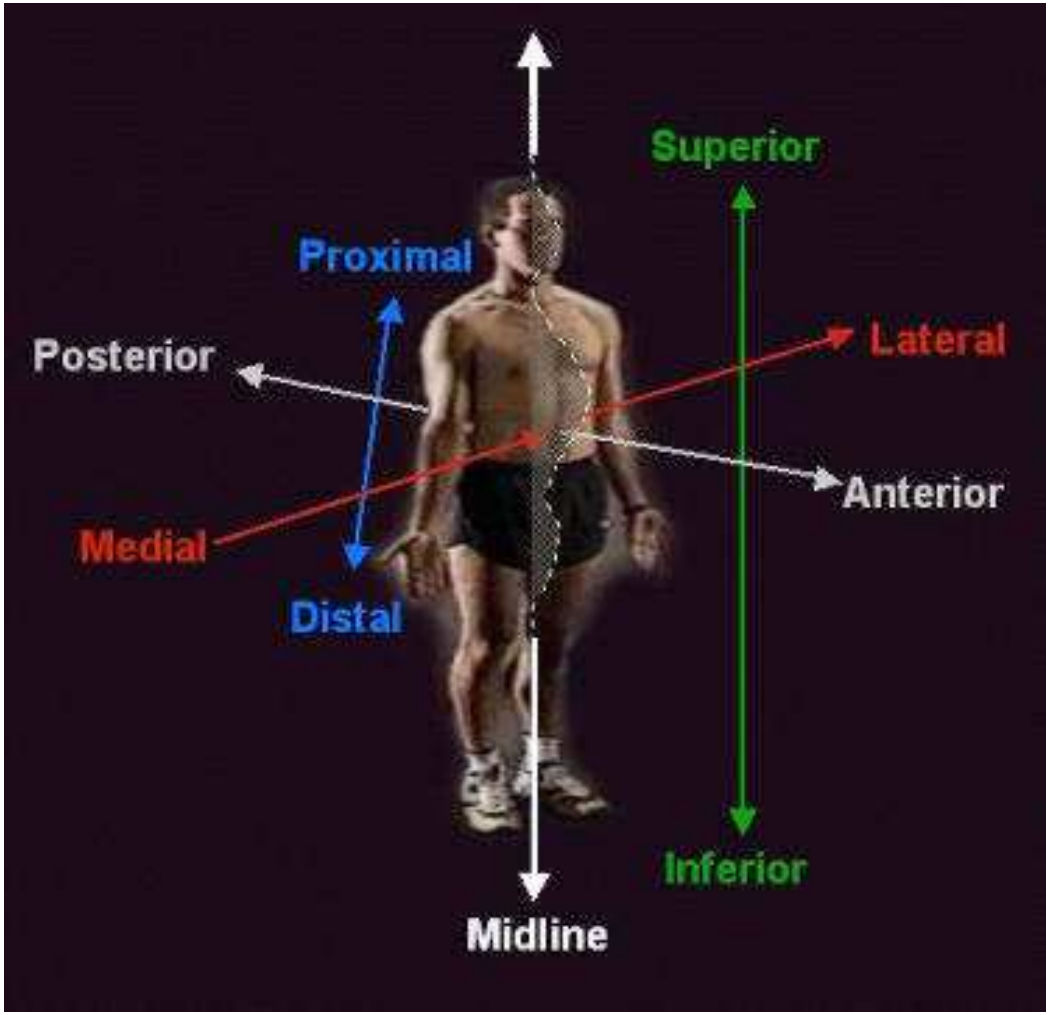




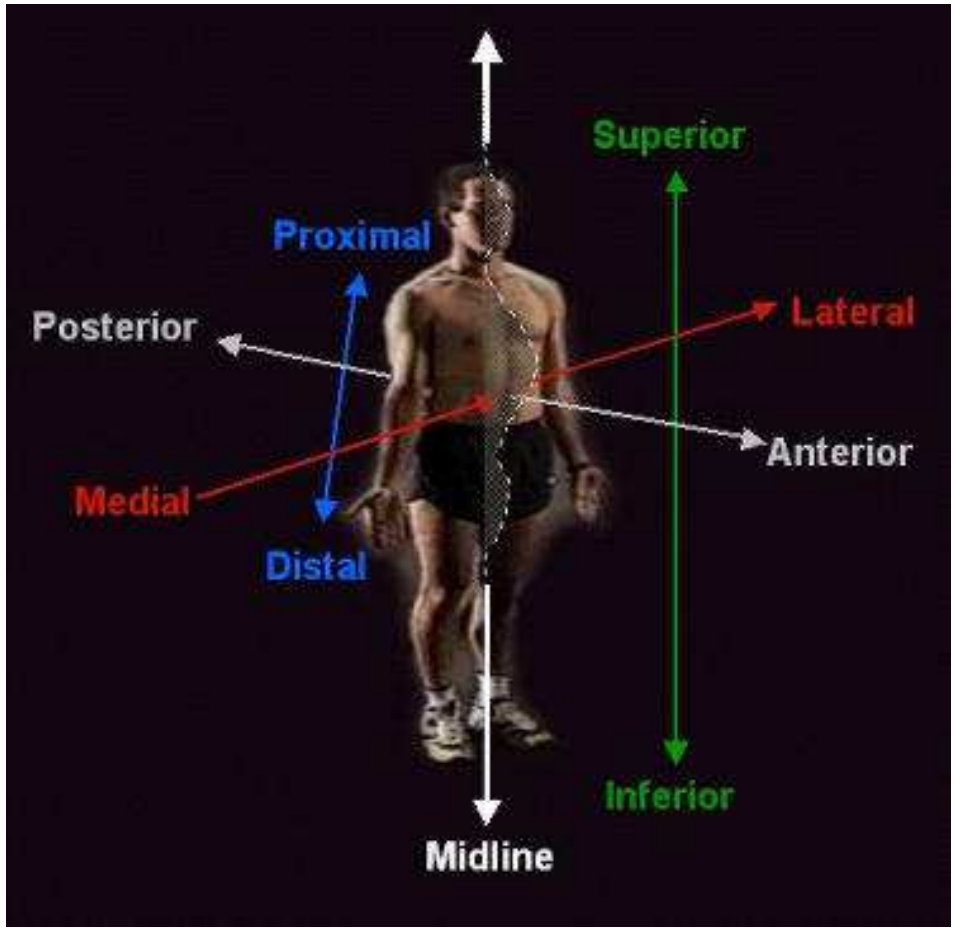


Orientation

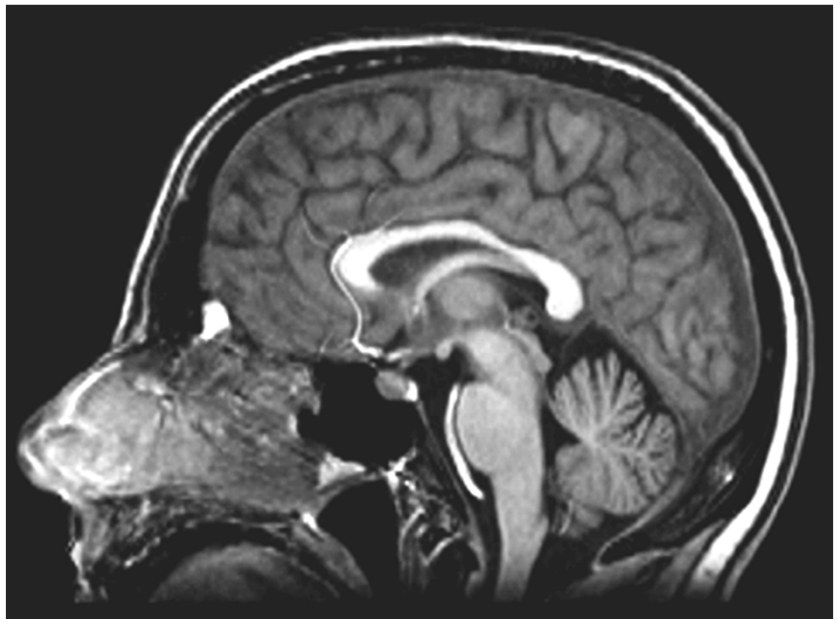
- terminologie anatomique
- Indique la position d'une structure par rapport à une autre



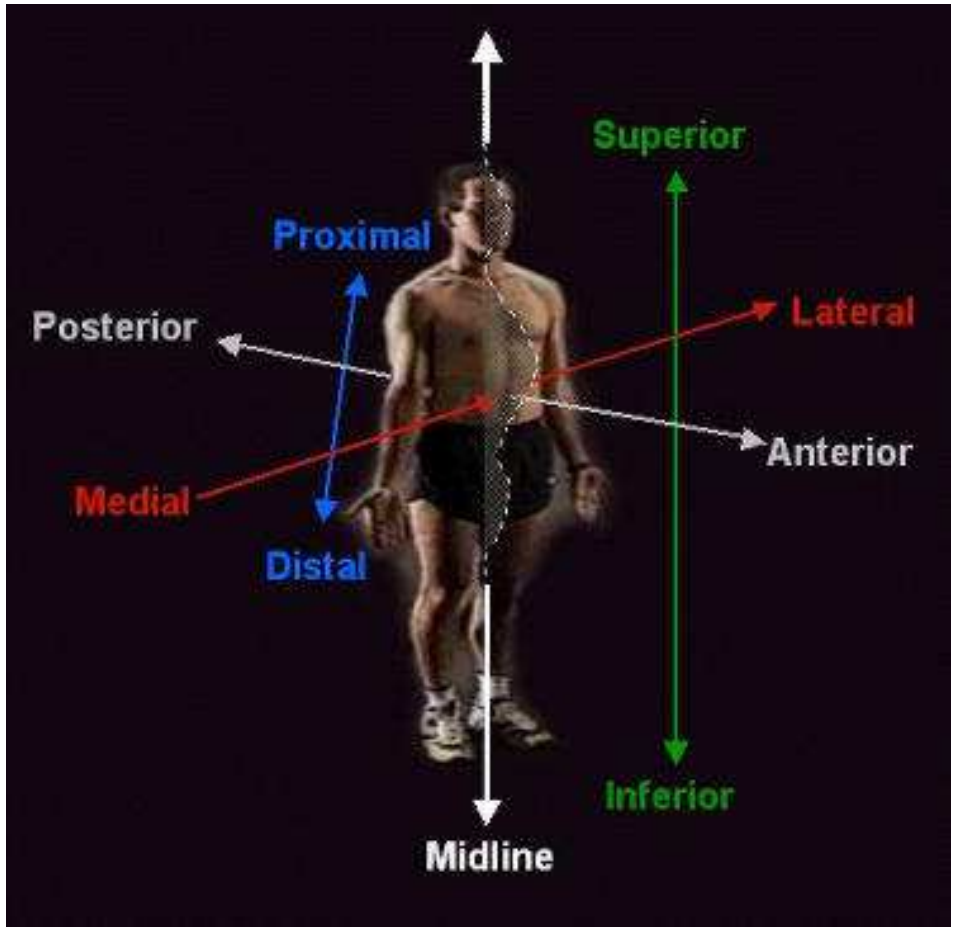
Crânial, Crânien, Supérieur, céphalique



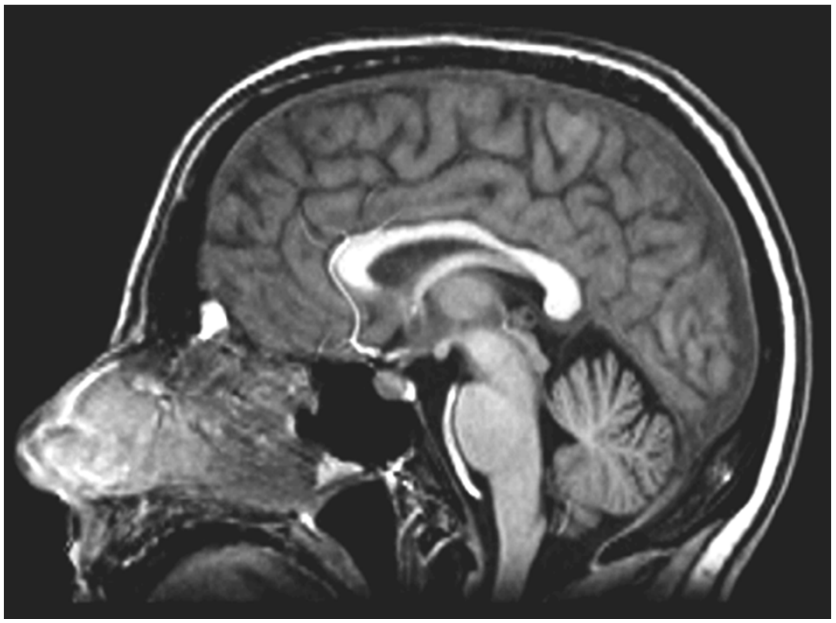
- Vers la tête
- Vers le haut d'une structure



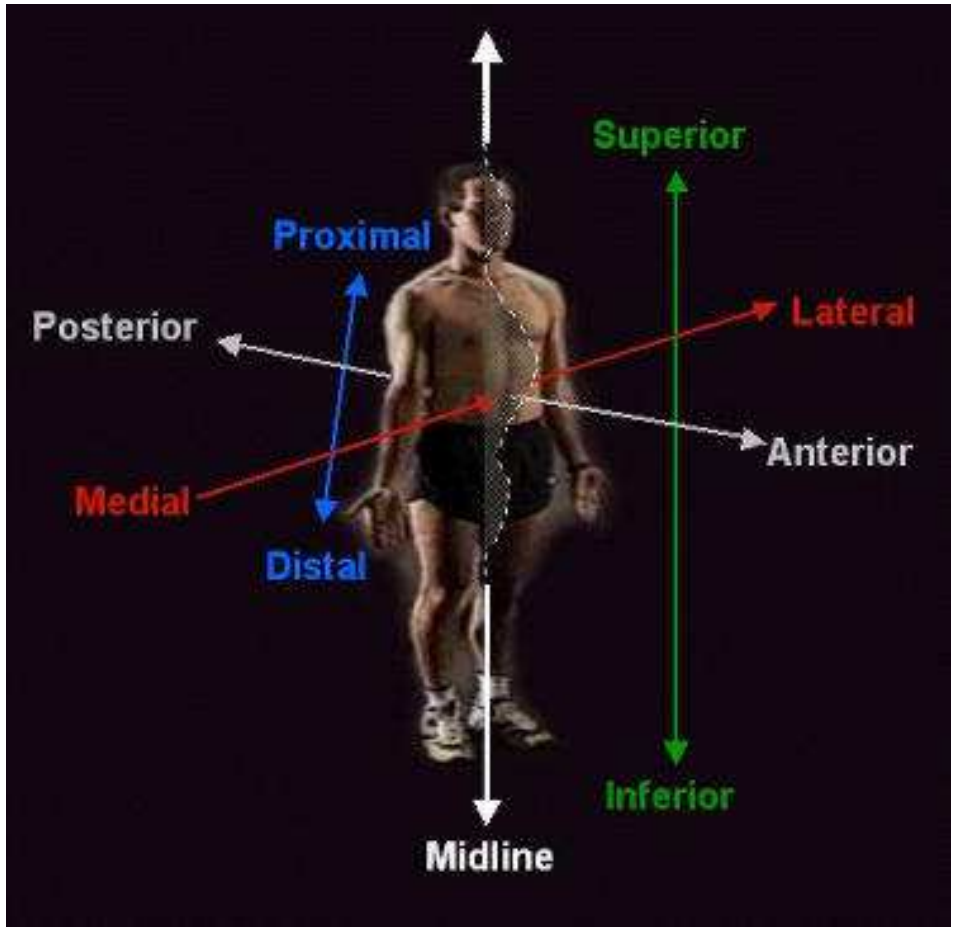
Inférieur ou caudal



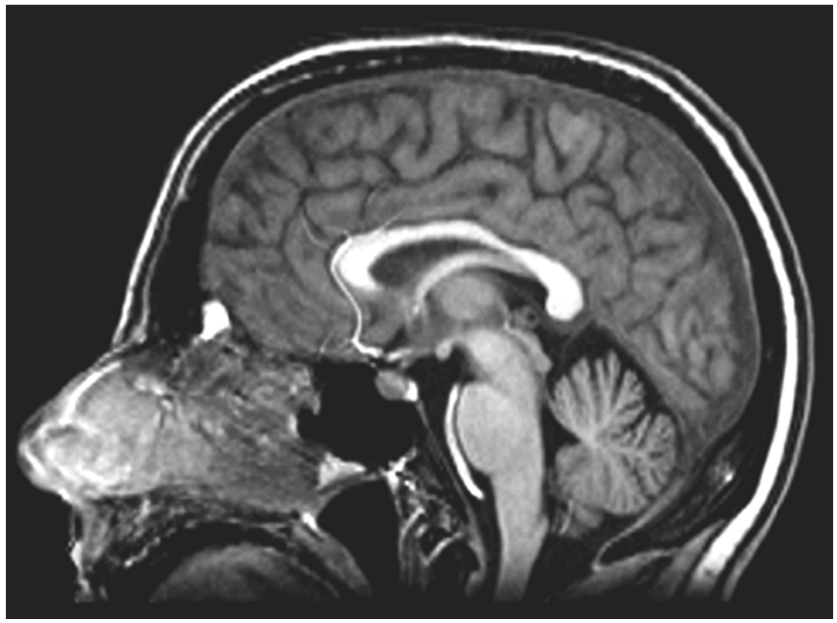
- À l'opposé de la tête
- Vers le bas



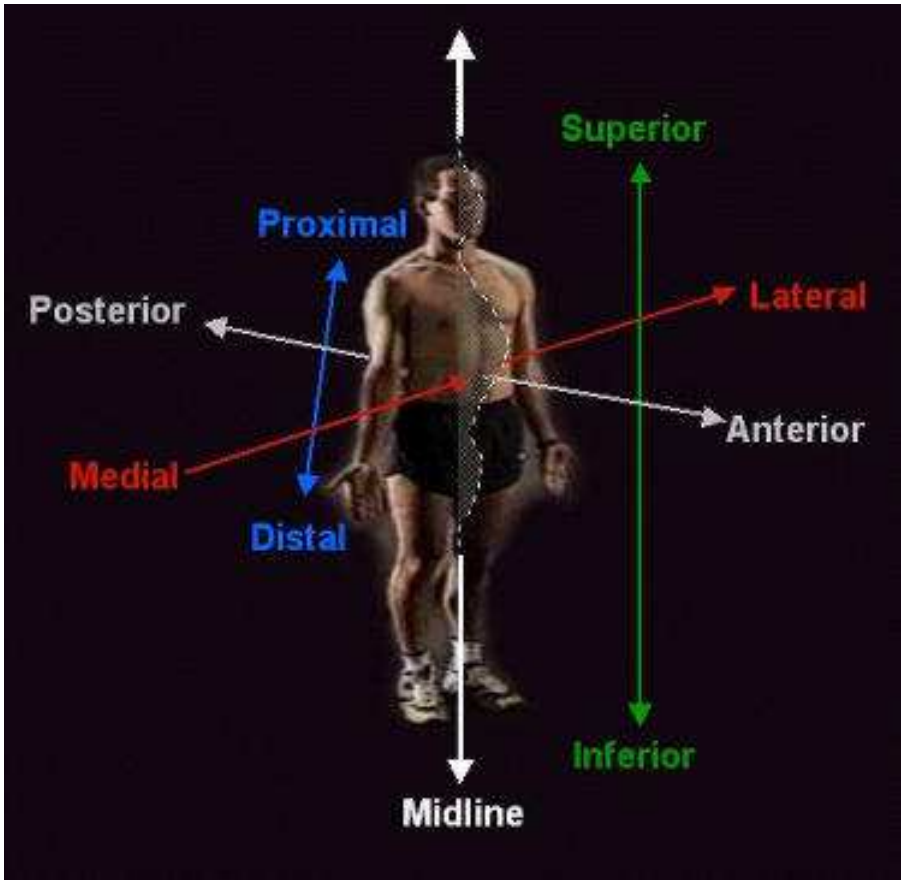
Antérieur ou ventral



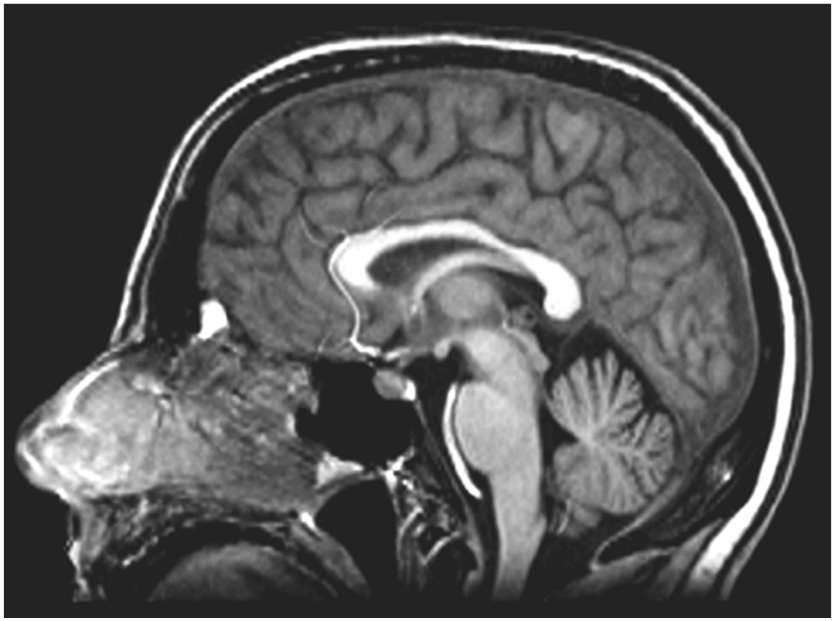
- Vers l'avant



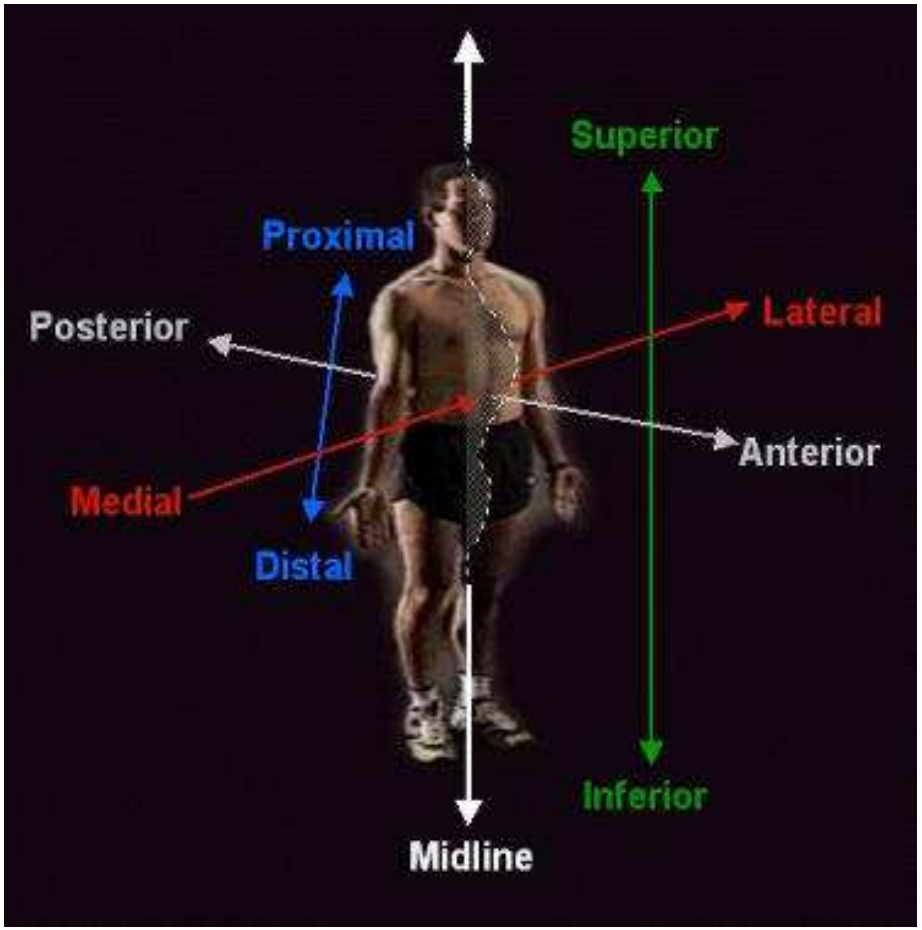
Postérieur ou dorsal



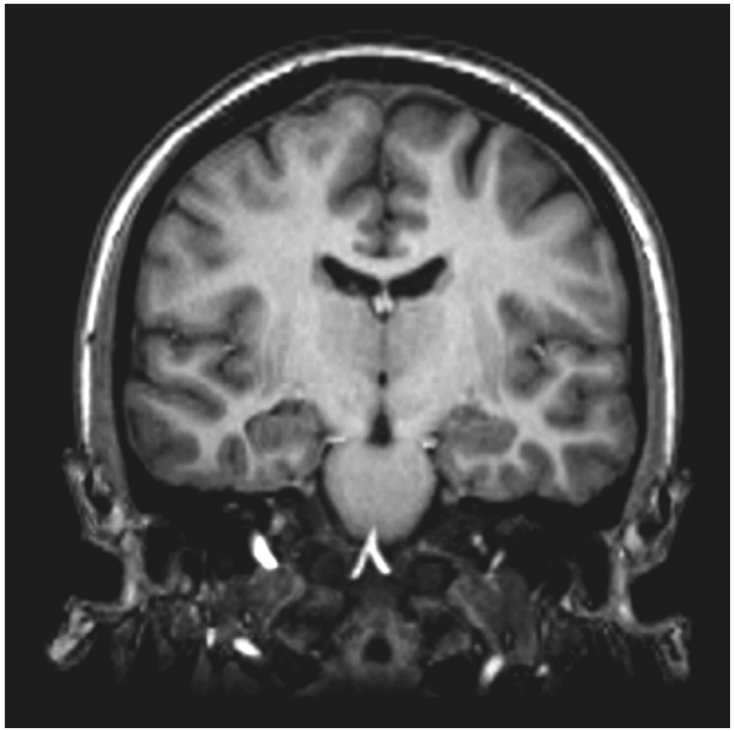
- Vers le dos
- Au dos du corps



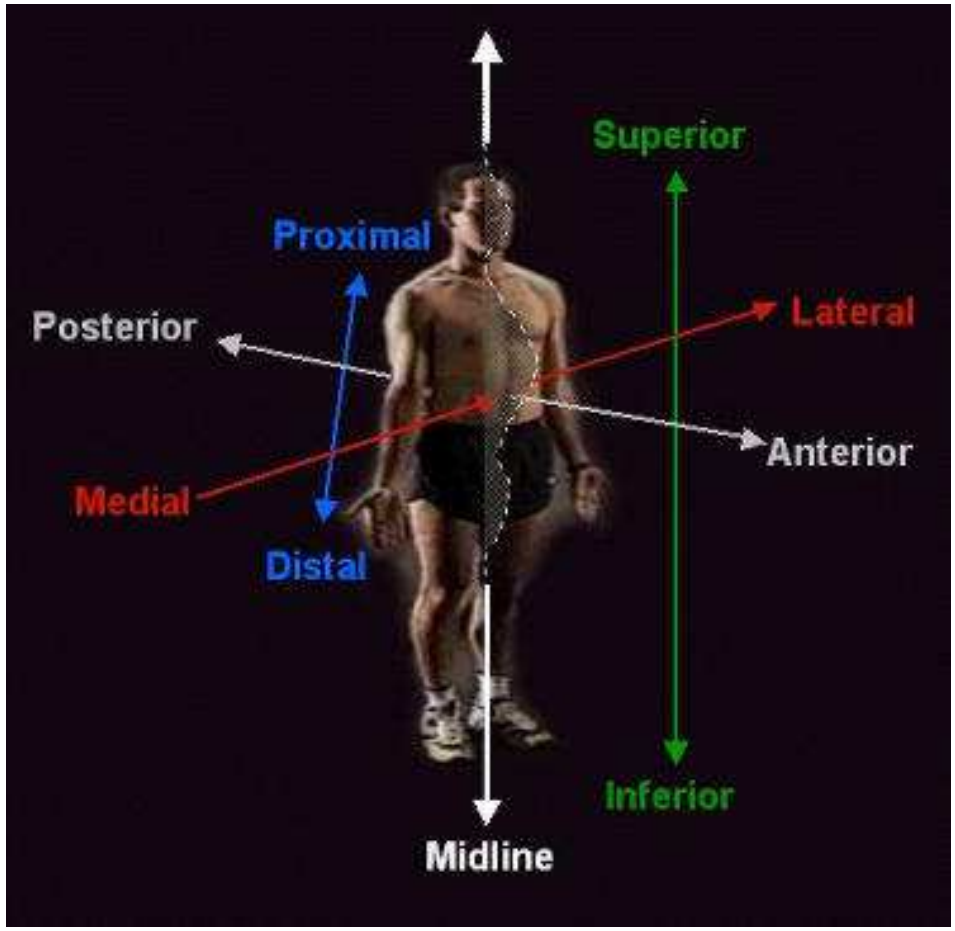
Médian ou médial



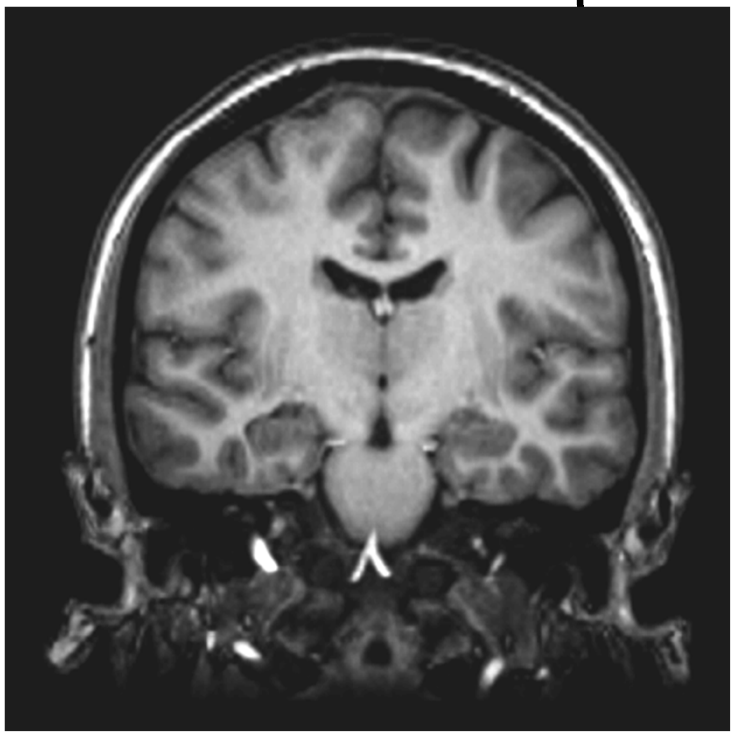
- Près de l'axe central du corps



Latéral



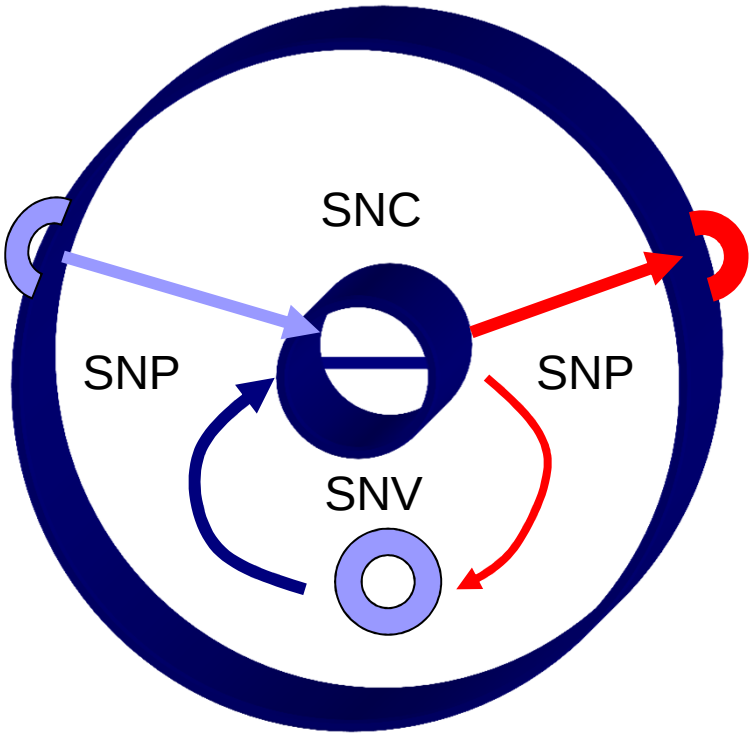
- Opposé au plan médian du corps



ORGANISATION GÉNÉRALE DU SYSTÈME NERVEUX

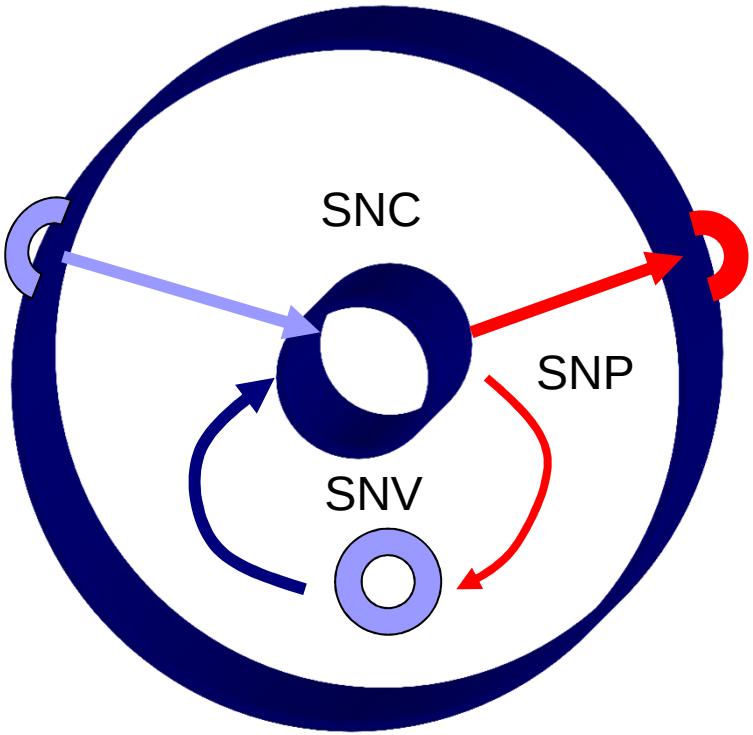
Les grandes fonctions du système nerveux

- Réception
- Conduction
- Intégration
- (Conduction) Réponse



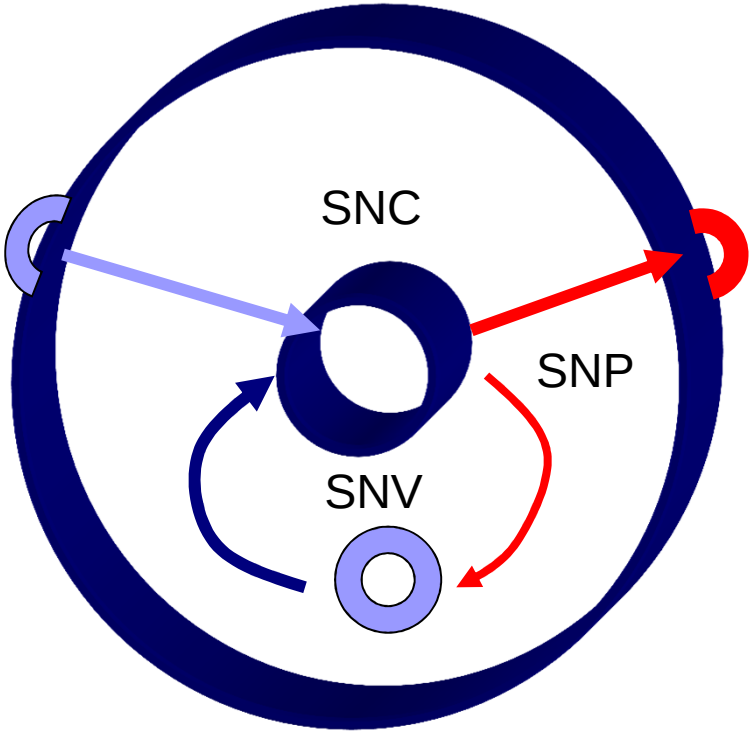
Trois subdivisions anatomiques

- ***Système nerveux central***
- ***Système nerveux périphérique***
  - Afférences
  - efférences
- ***SN végétatif (autonome)***
  - Sympathique
  - para sympathique



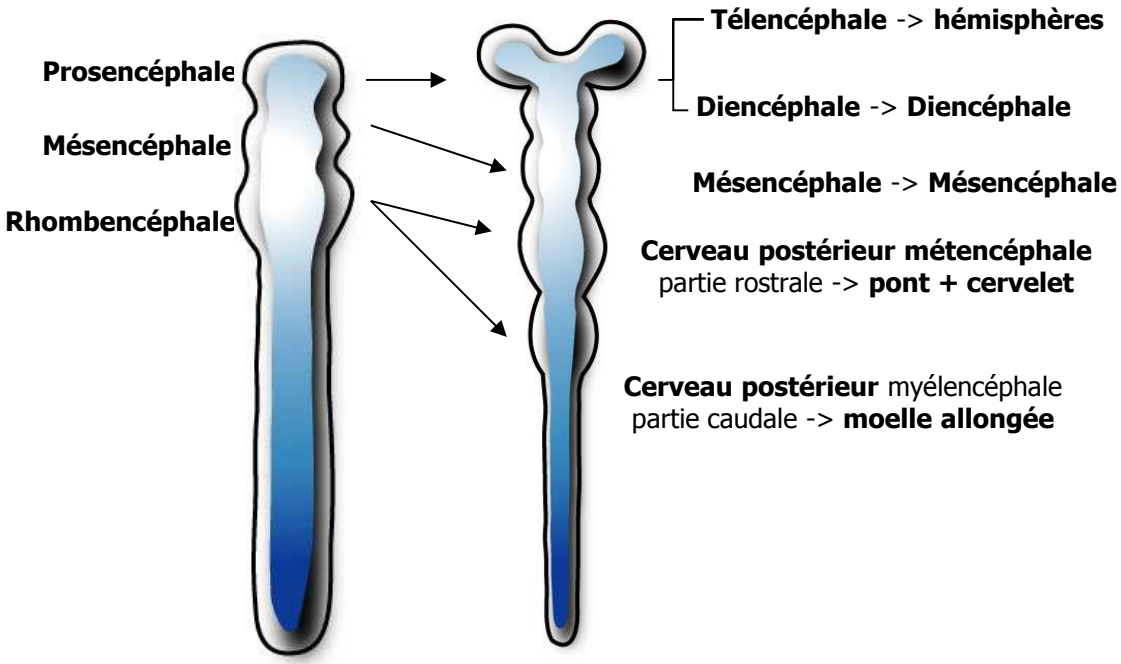
Deux subdivisions fonctionnelles

- ***Système somatique***
- ***Système viscéral***

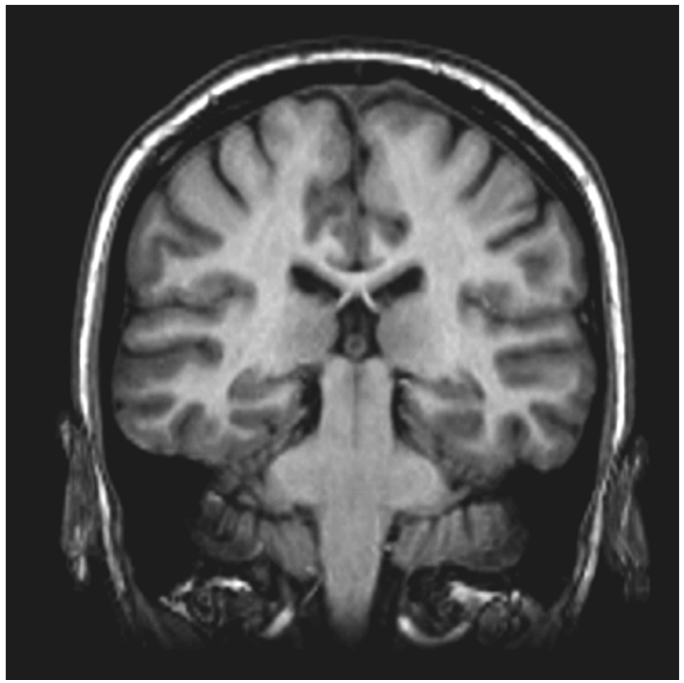


INTRODUCTION À L'EMBRYOLOGIE DU SYSTÈME NERVEUX

Tube neural et vésicules

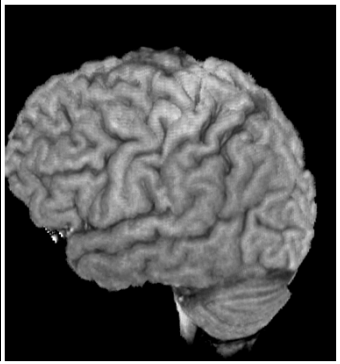


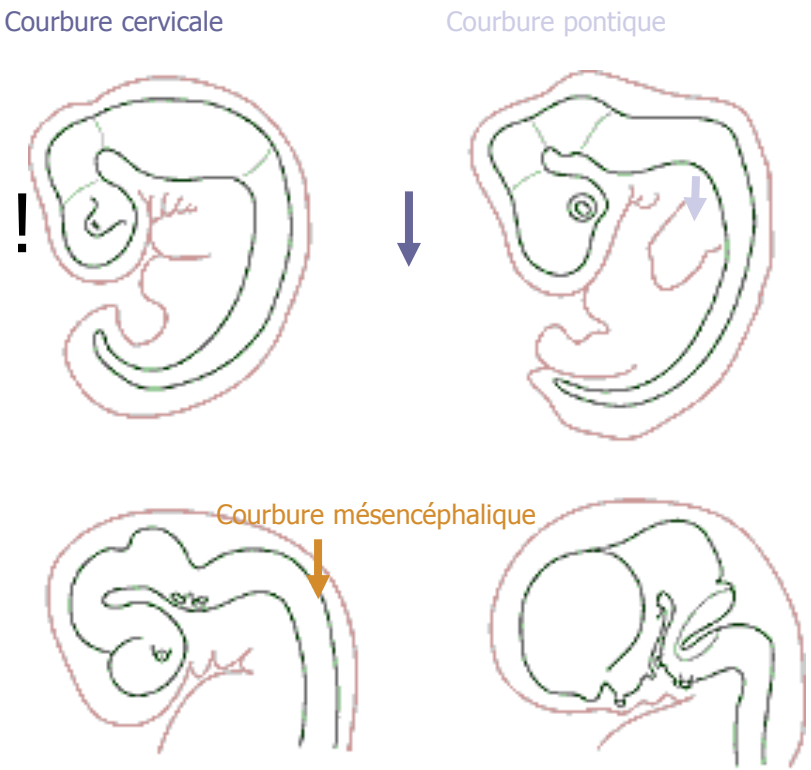
Tube neural
Stade 3 vésicules – stade 5 vésicules



Courbures

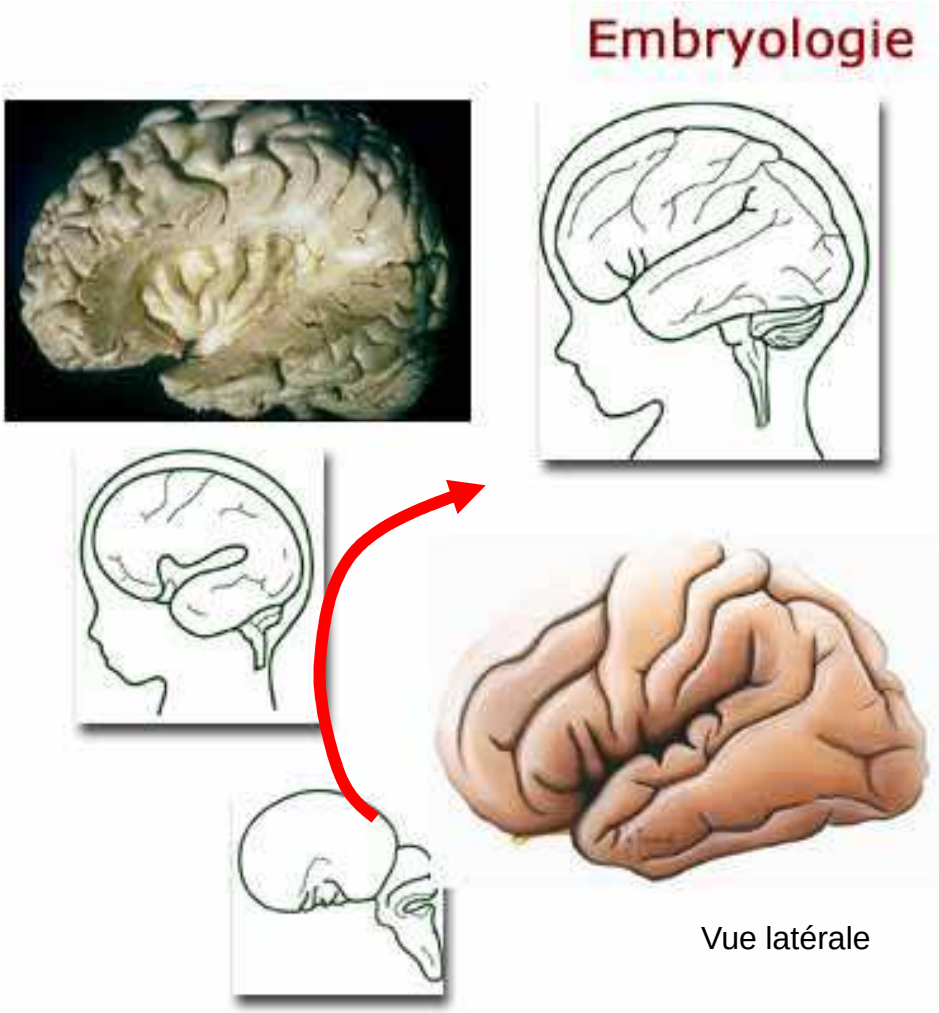
- Modification des axes !





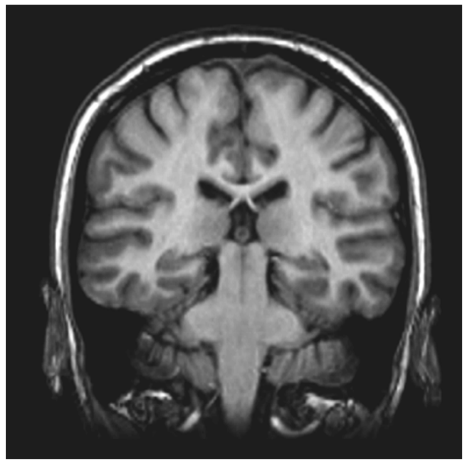
Développement du télencéphale

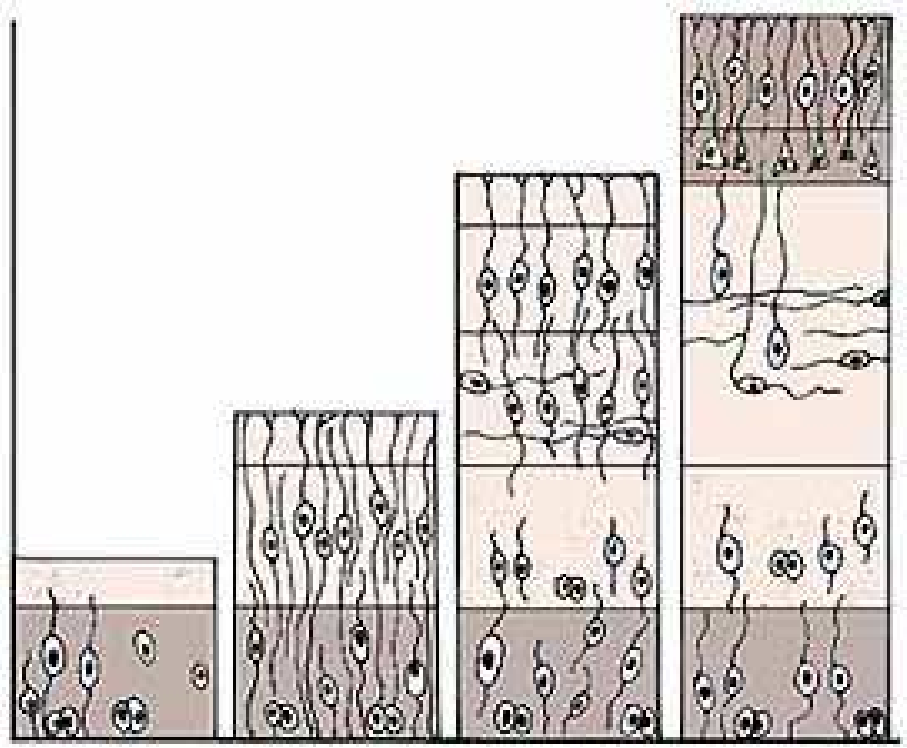
- Lobe temporal apparaît
- Sillon latéral
- Insula enfouie
- Structures en fer à cheval
  - Ventricules Latéraux
  - Noyau caudé



Développement du cortex

- Glie radiaire
  - Zone marginale -> périphérie
- Migration des neuroblastes

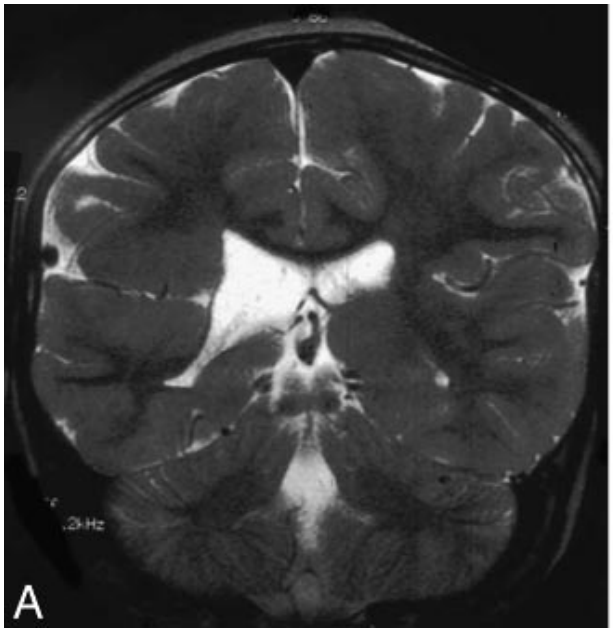


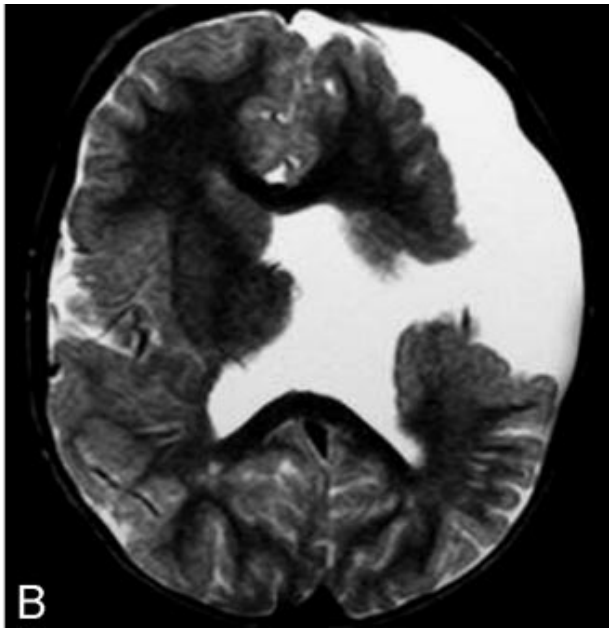


Glie radiaire – migration des neuroblastes

Anomalies de la gyration

Polymicrogyrie

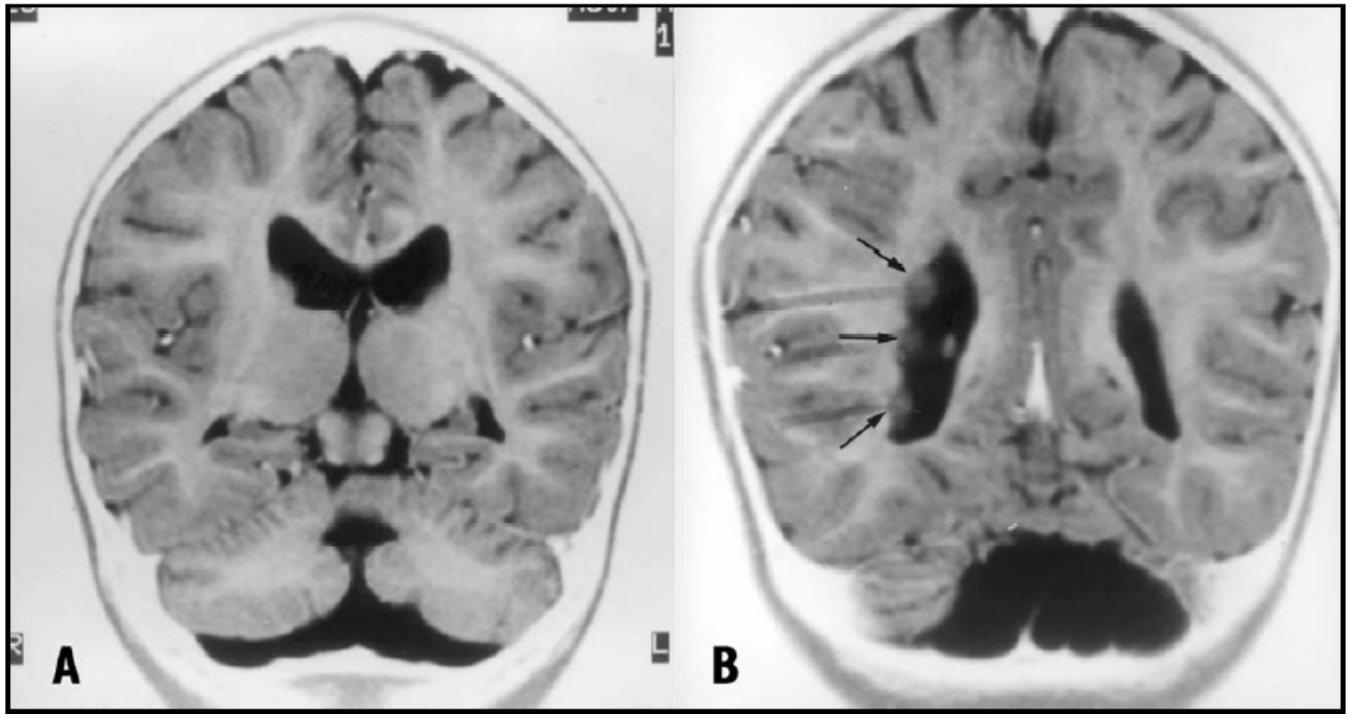




Schizencéphalie

Hétérotopie sous corticale

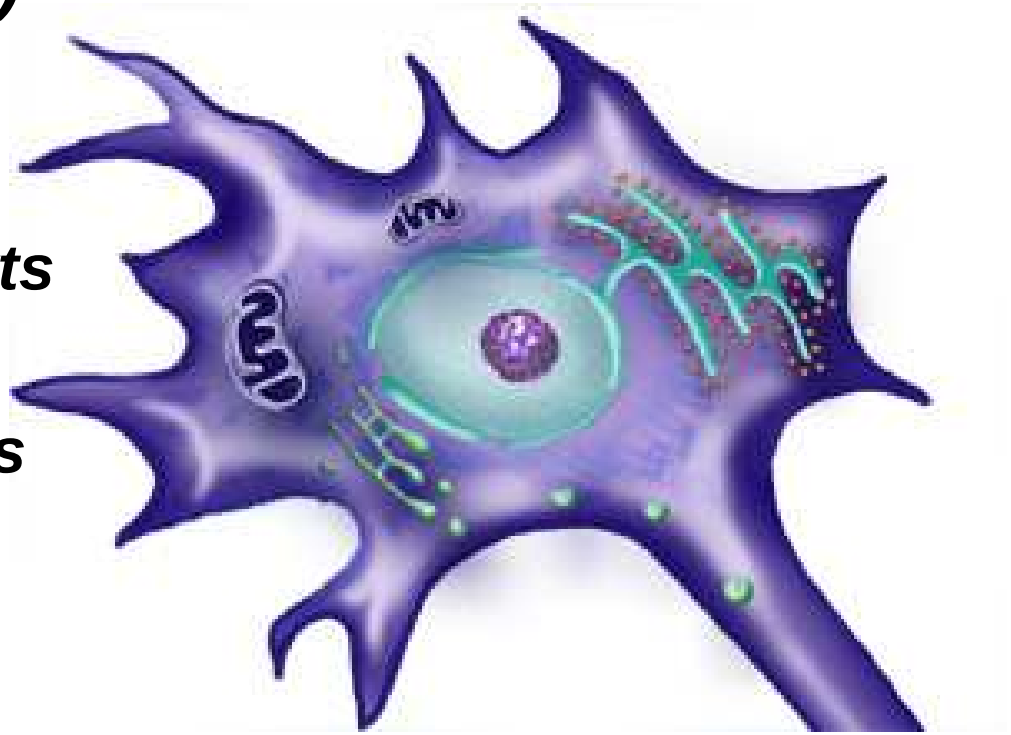
- Nodulaire
- Laminaire : double cortex



LE NEURONE

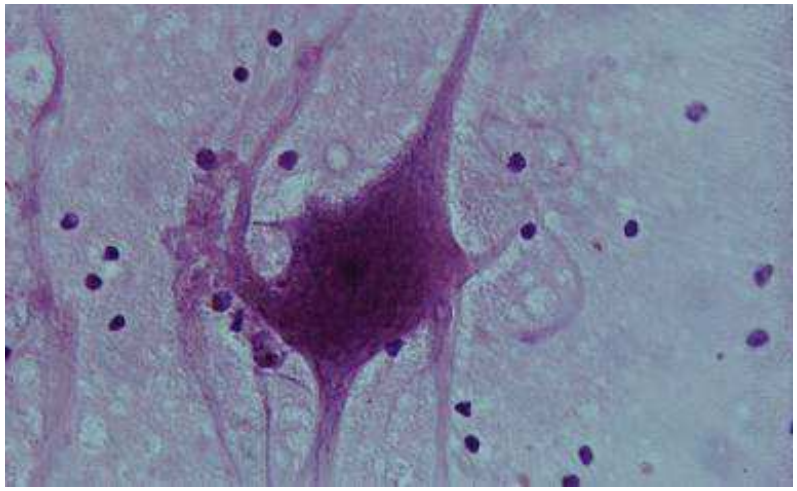
Histologie : neurones et glie

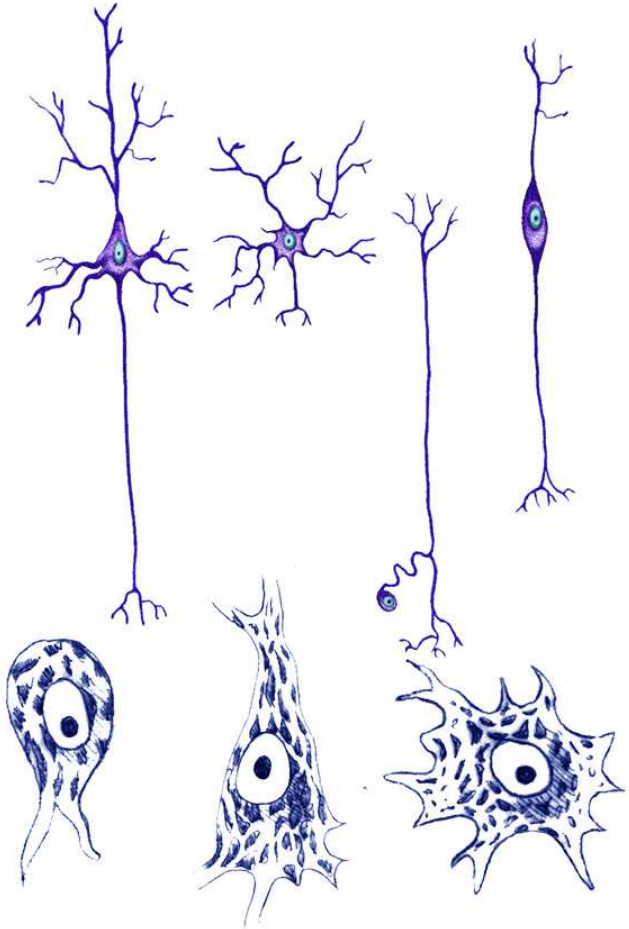
- ***soma (corps cellulaire)***
- ***Prolongements :***
  - ***Dendrites***
    - ***Prolongements courts***
  - ***Axones***
    - ***prolongements longs (conduction de la réponse)***



Classification des neurones

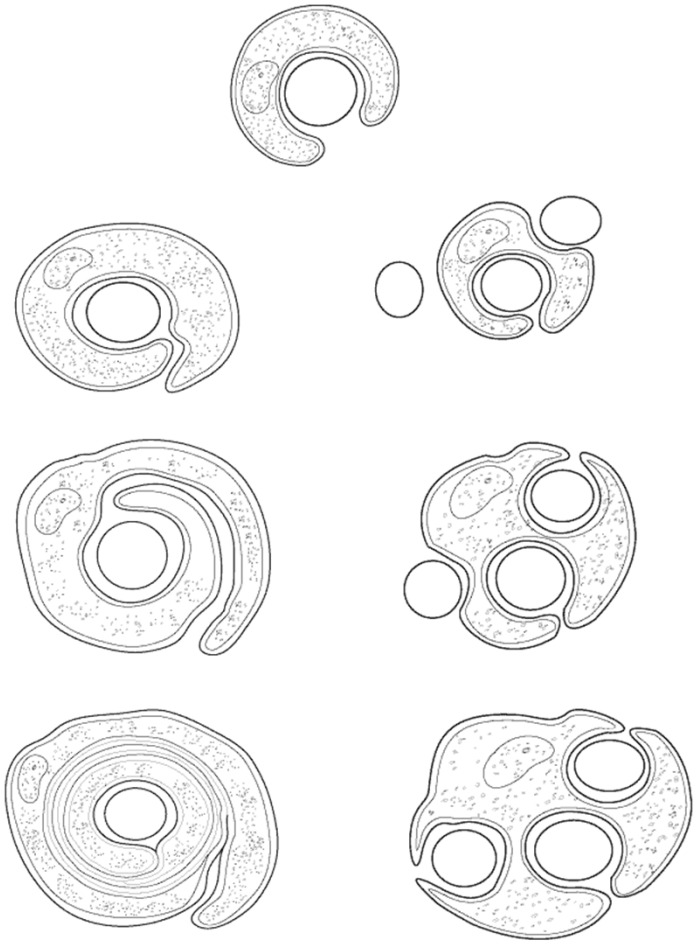
- ***selon le corps cellulaire***





Classification des neurones

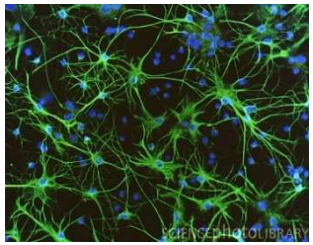
- ***selon l'axone***
  - ***Myélinisé***
  - ***amyélinique***



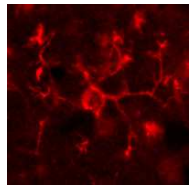
TISSU GLIAL

Glie centrale

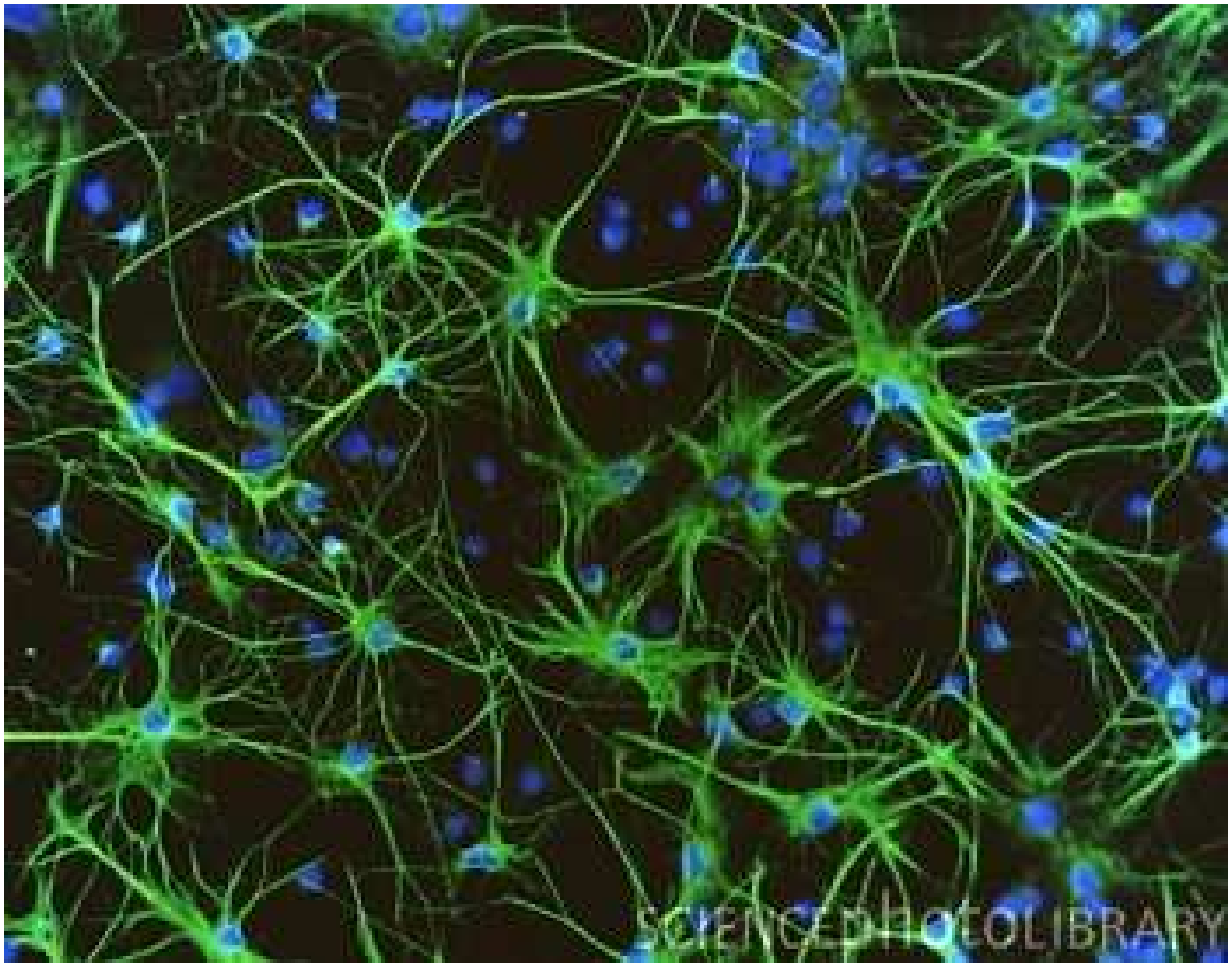
- ***Les astrocytes (macroglie)***



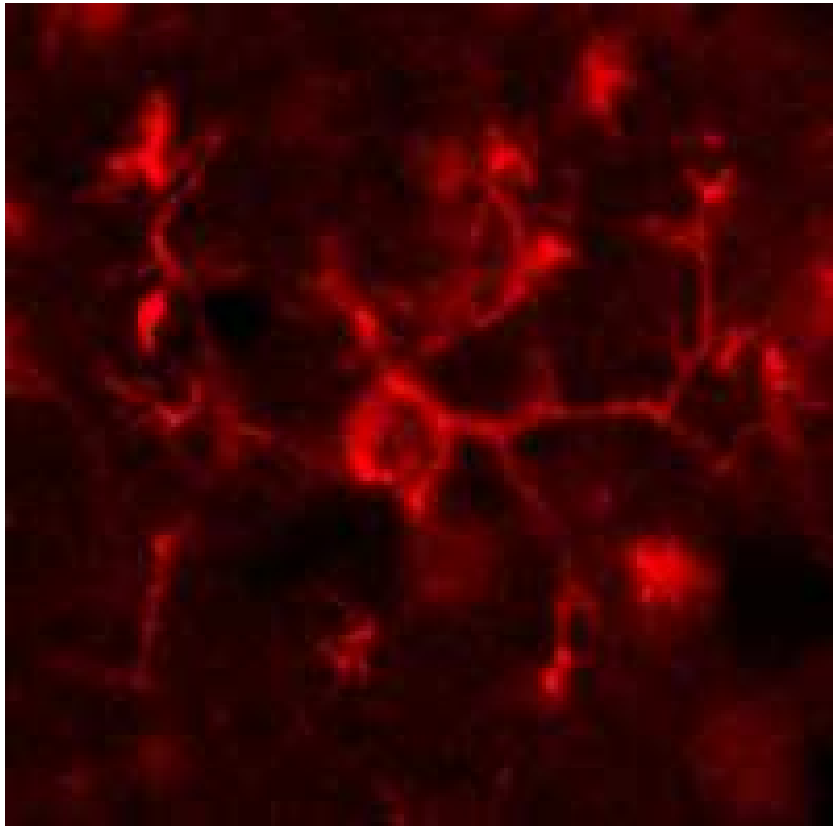
- ***Les oligodendrocytes (oligodendroglie)***
- ***Les microgliocytes (microglie)***

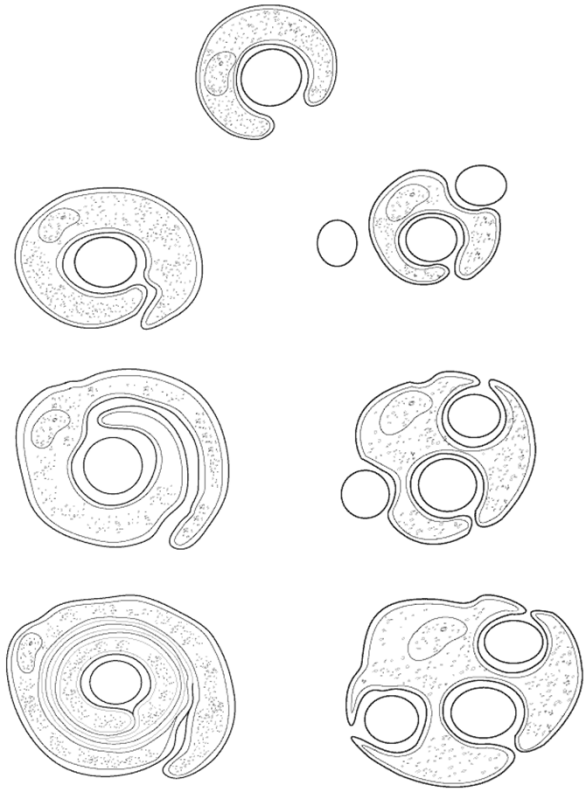


Astrocytes



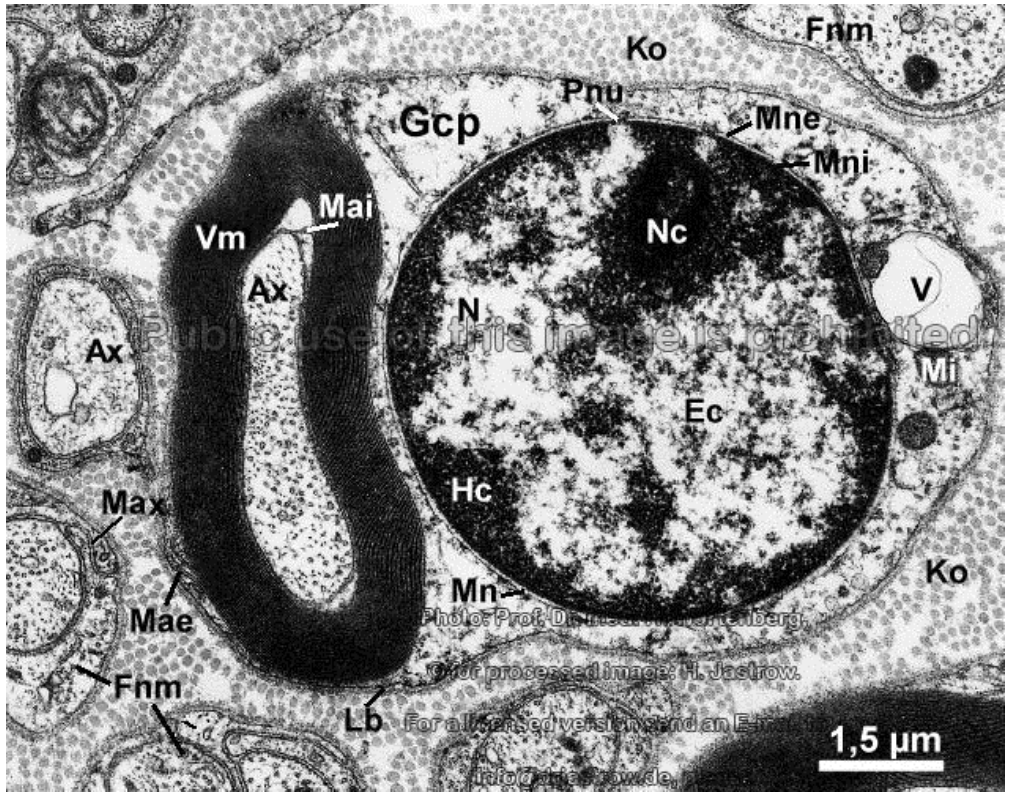
Oligodendrocytes

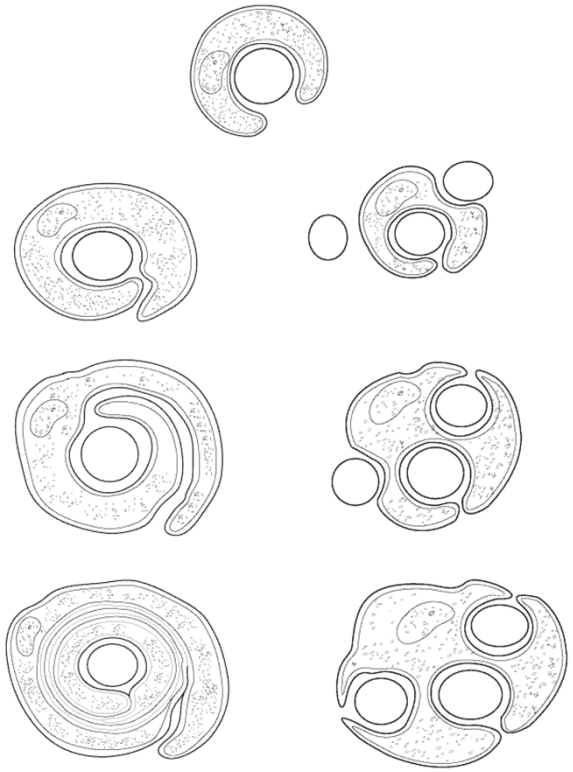




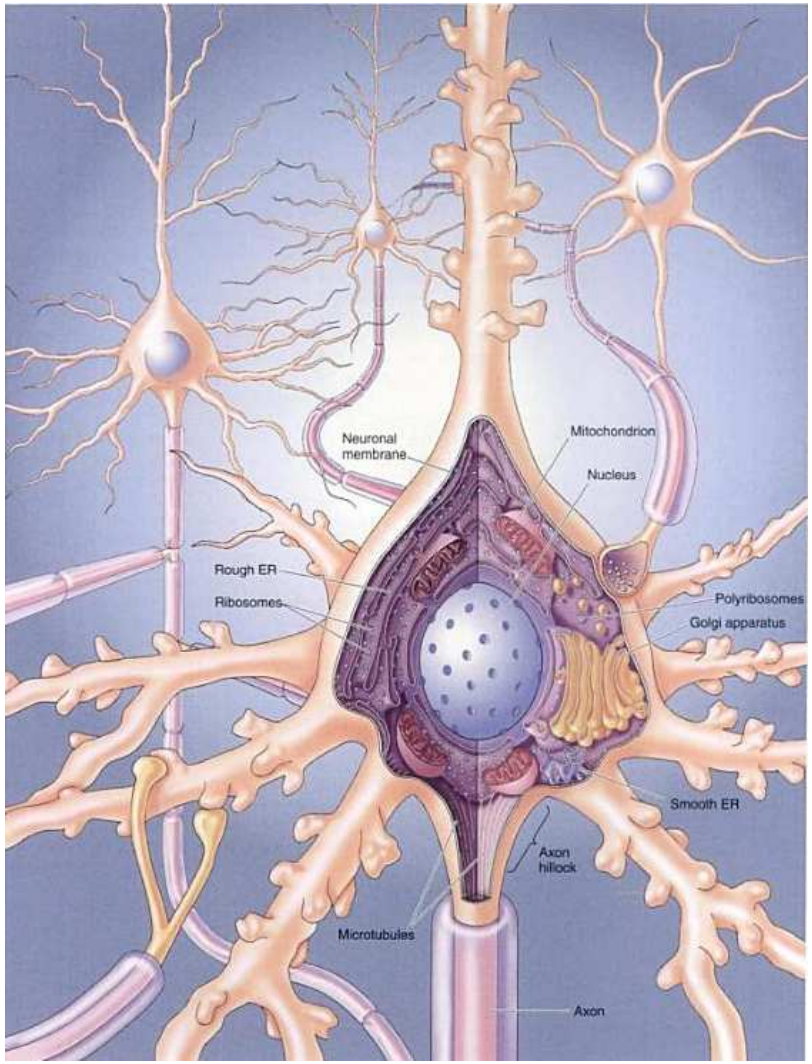
Glie périphérique

- cellules de Schwann





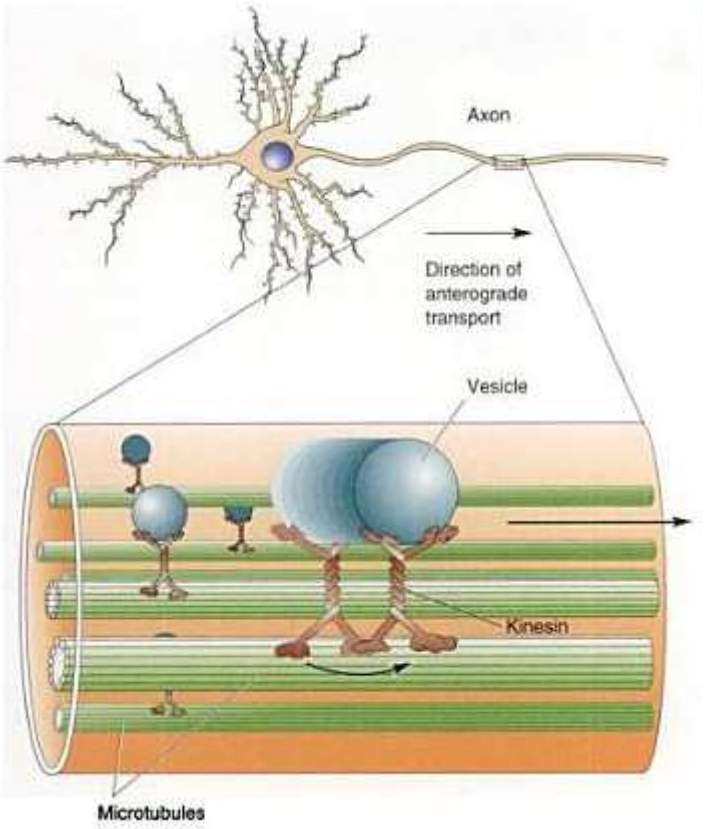
Neurobiologie du neurone



Neuroscience: exploring the brain Mark F. Bear,Barry W. Connors,Michael A. Paradiso

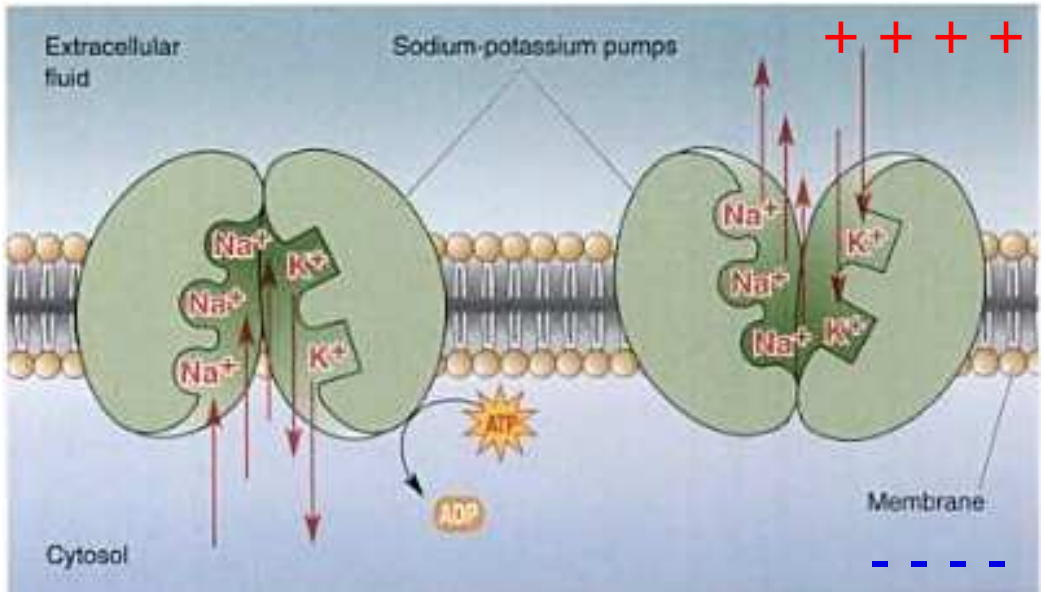
Flux axoplasmiques

- Transport axoplasmique
  - Antérograde : kinesine
  - Rétrograde : dyneine
- Traçage
  - Horse Radish Peroxydase (HRP)…



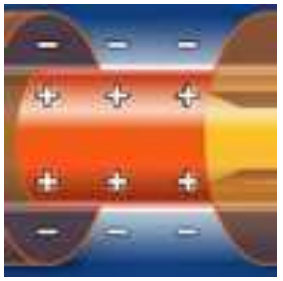
Potentiel de membrane

- $[K^+]_{IC}$ +++
- $[Na^+]_{EC}$ +++
- $[Ca^{2+}]_{EC}$ +++

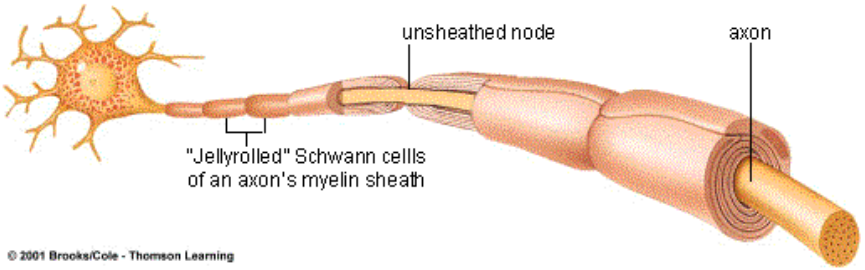


- Gradient de concentration d'ions K^+
- Au repos : membrane perméable au K

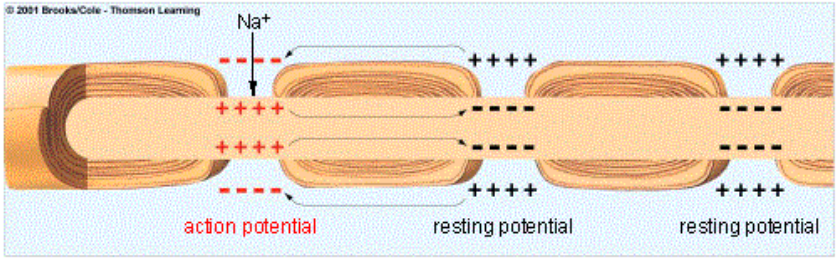
Influx nerveux

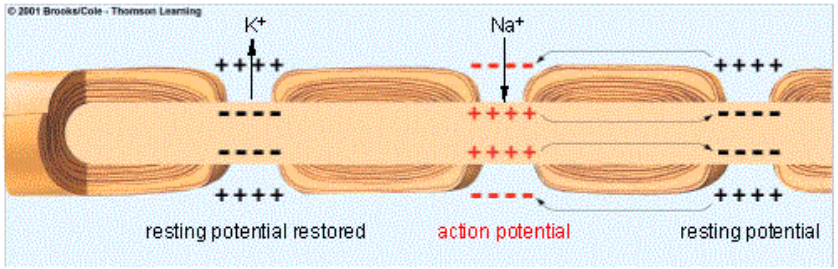


- Conduction saltatoire



- De proche en proche



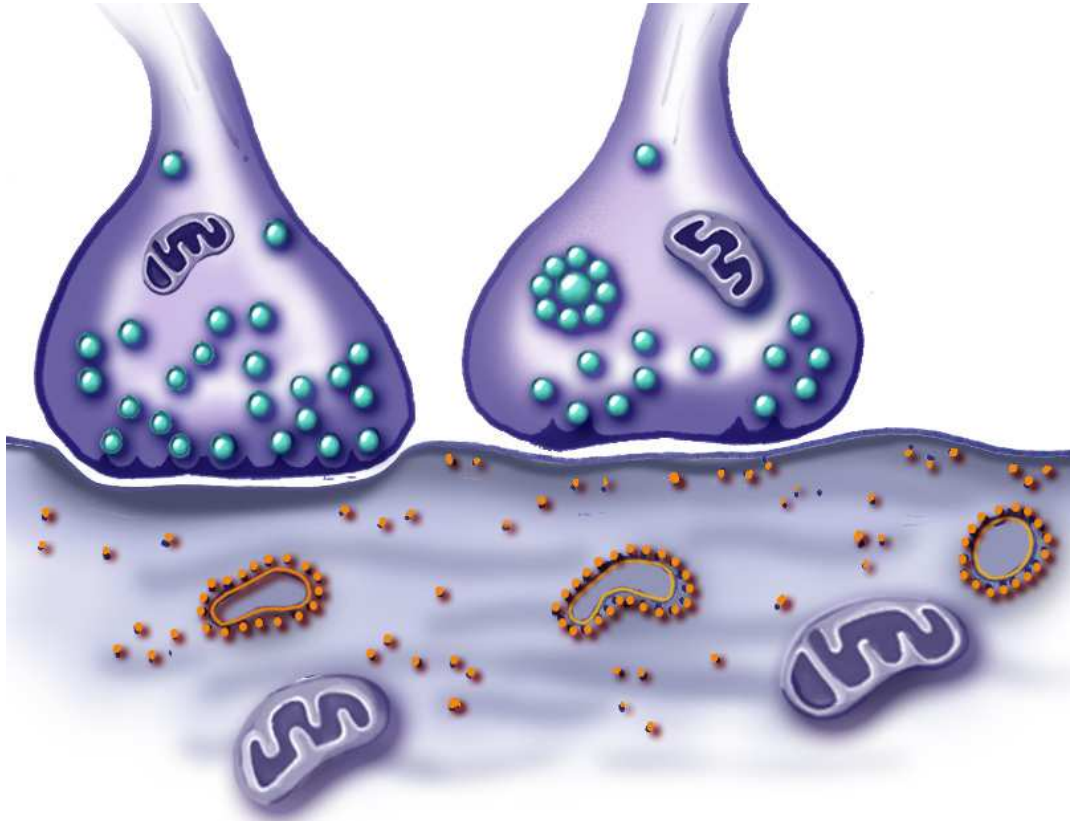


Synapses

- Chimiques
- Électriques
- Ephapse : connexion post-lésionnelle entre 2 fibres nerveuses

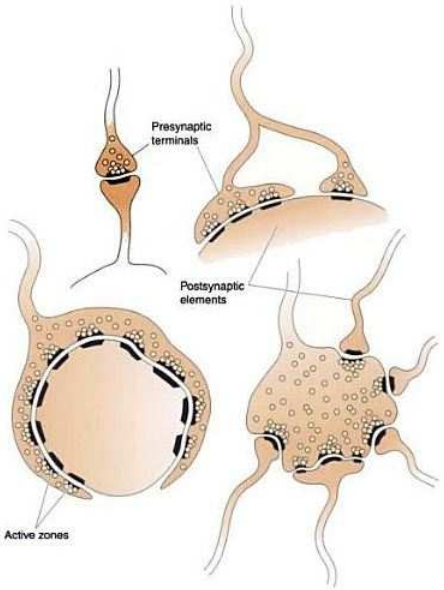
Synapses

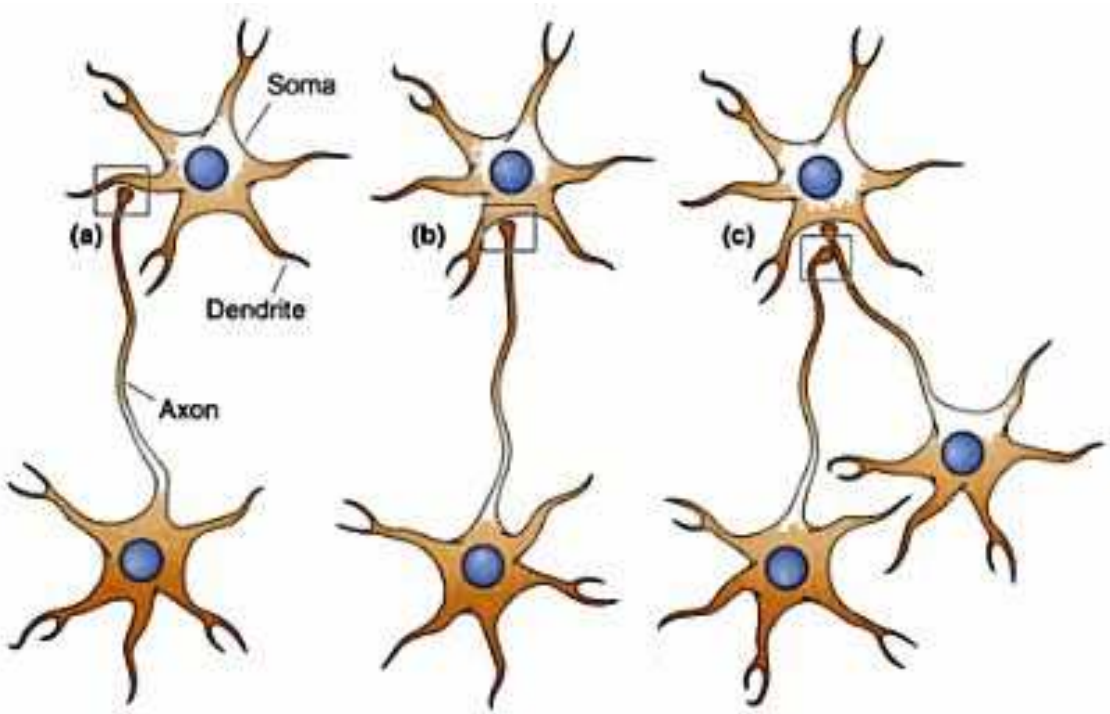
- Présynaptique
- Fente synaptique
- Postsynaptique
  - récepteurs ionotropes : protéines-canal
  - récepteurs métabotropes : couplés aux proteines G (transducteurs de signal régulant des seconds messagers dans le cytoplasme)



synapses

- Axodendritiques
- Axosomatiques
- Axoaxoniques
- Morphologie variée



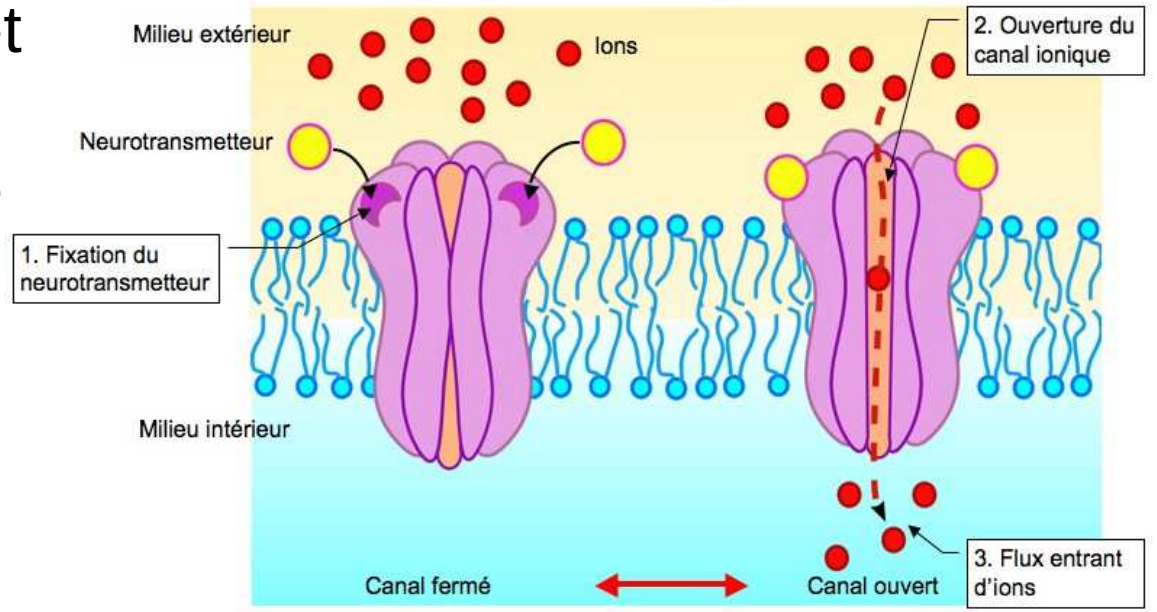


neurotansmetteurs

- les monoamines : synthétisées à partir d'un acide aminé :
  - catécholamines sont dérivées de la tyrosine :
    - dopamine,
    - noradrénaline,
    - adrénaline (épinephrine et norépinephrine sont des francisations des termes anglais).
  - sérotonine (5-HT) dérive du tryptophane
  - GABA dérivé de l'acide glutamique
  - histamine dérivée de l'histidine
- endorphines, molécules similaires aux opiacés
- acides aminés : acide glutamique, acide aspartique, glycine
- substances chimiques diverses : acétylcholine, adénosine, anandamide (cannabinoïde endogène, cacao)

Récepteurs Ionotropes

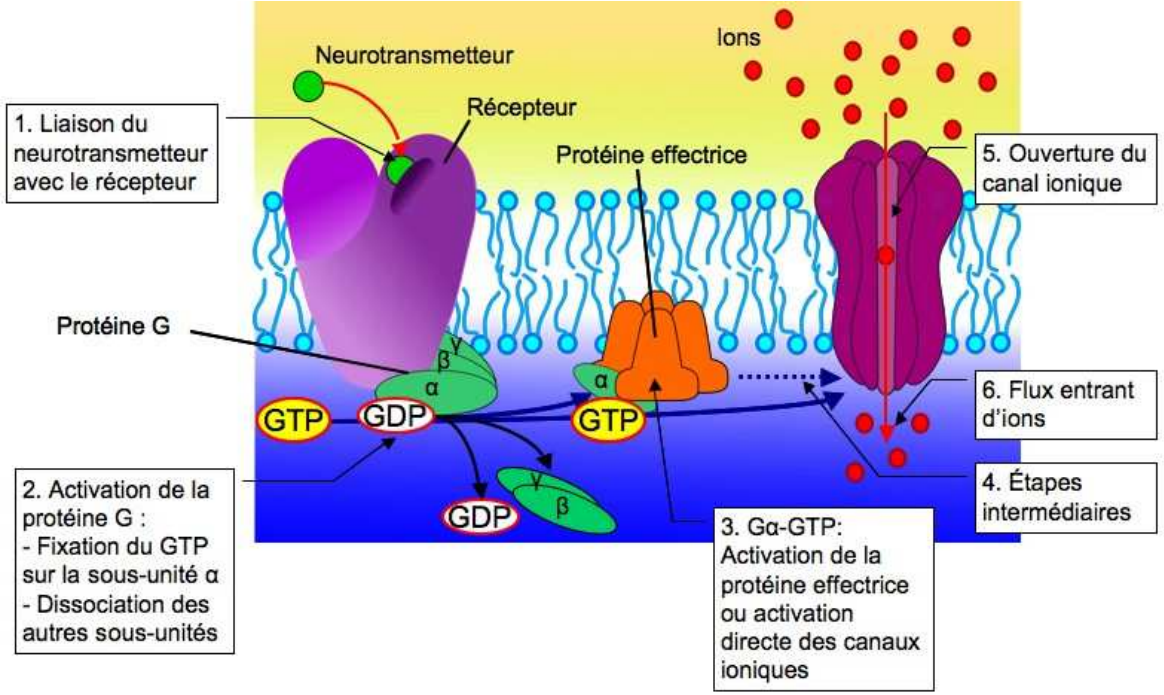
- comportant à la fois la molécule réceptrice et le canal ionique
- réponse rapide (1 à 2 ms) et
- brève (quelques dizaines de ms)



D'après Neurosciences. Purves, Augustine, Fitzpatrick, Hall, LaMantia, McNamara. de Boeck, collection Neurosciences & Cognition

Récepteurs Métabotropes

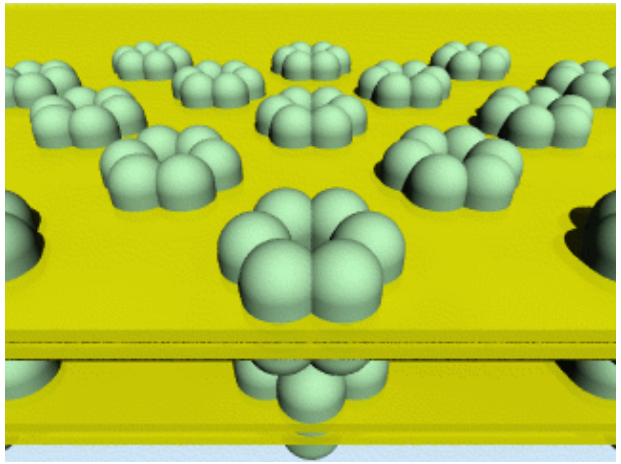
- Molécules distinctes pour le récepteur et le canal ionique
- Agissent indirectement sur des canaux ioniques postsynaptiques,
- Activent des molécules intermédiaires, des **protéines transductrices : protéines G**

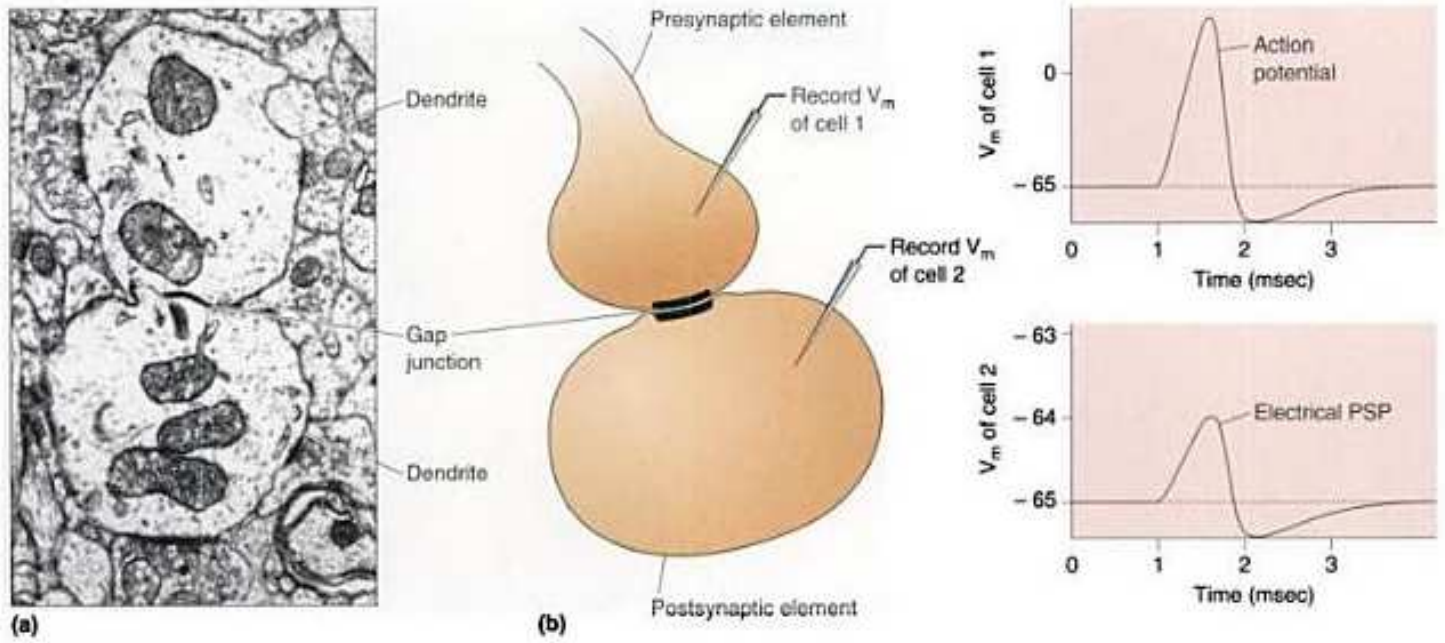


D'après Neurosciences. Purves, Augustine, Fitzpatrick, Hall, LaMantia, McNamara. de Boeck, collection Neurosciences & Cognition

Synapses électriques

- Jonction sérrée (gap junction)
- Connexon : 6 Connexines
- Échanges ioniques
- Couplage électrotonique

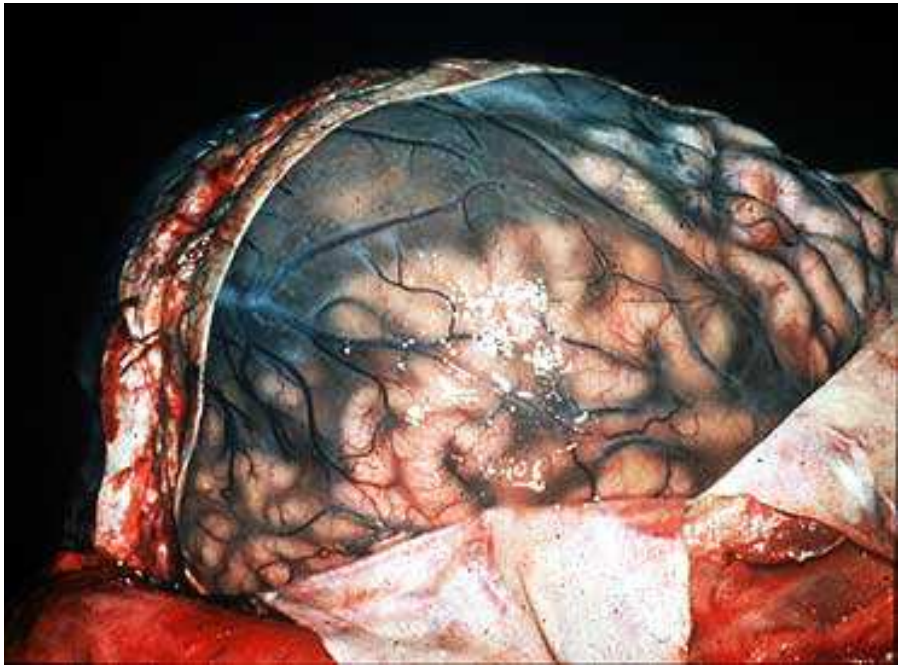


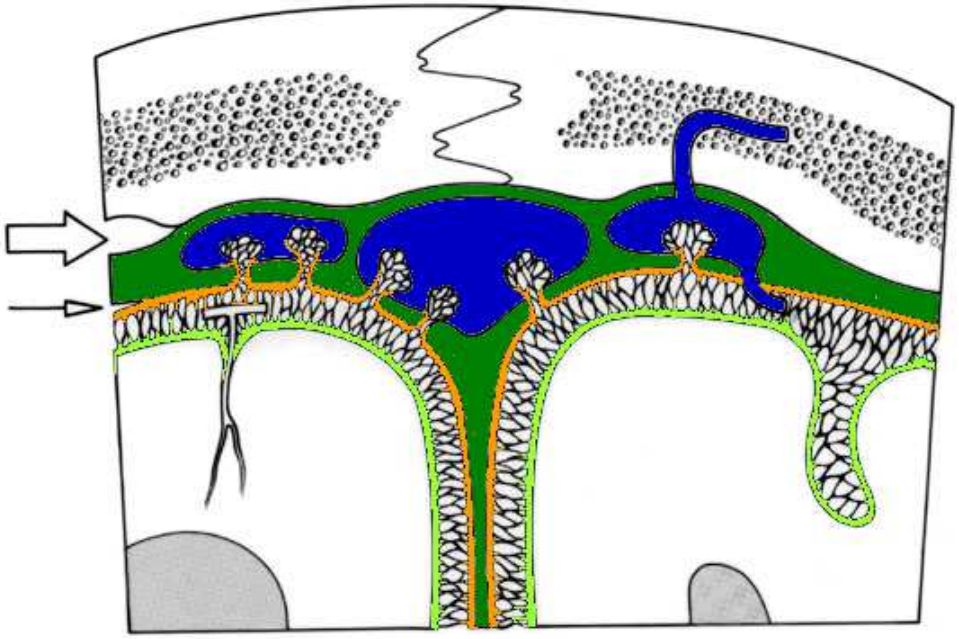


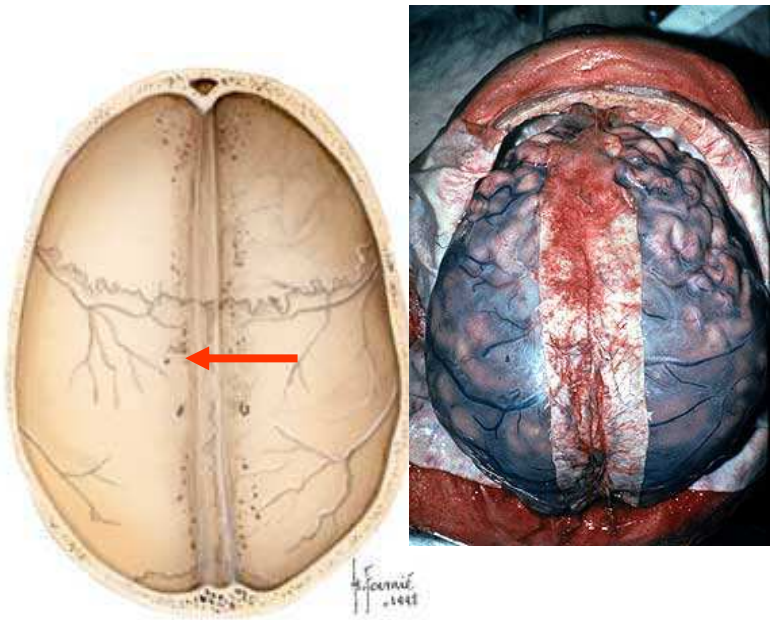
MÉNINGES

Méninges

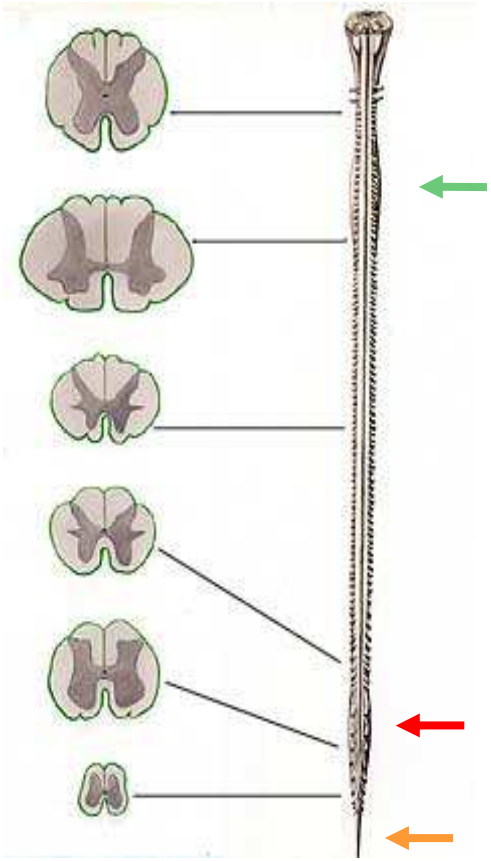
- Feuillets
  - Pachyméninge
    - Dure mère
  - Leptoméninge
    - Arachnoïde
    - Pie mère
- Espaces
  - Extra-dural
  - Sous-dural
  - Sous-arachnoïdien







Moelle spinale



H

B

Vue postérieure

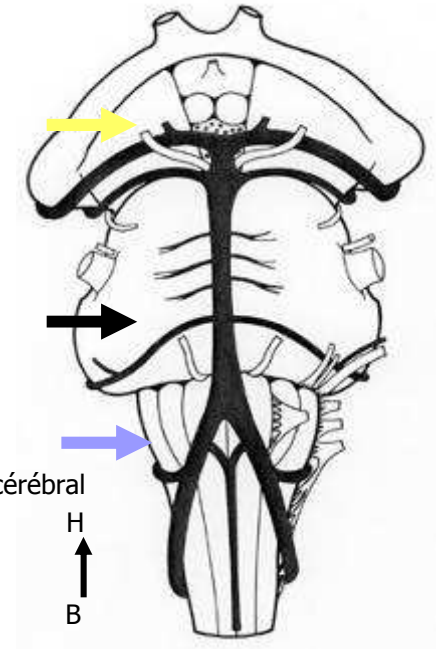
H

B

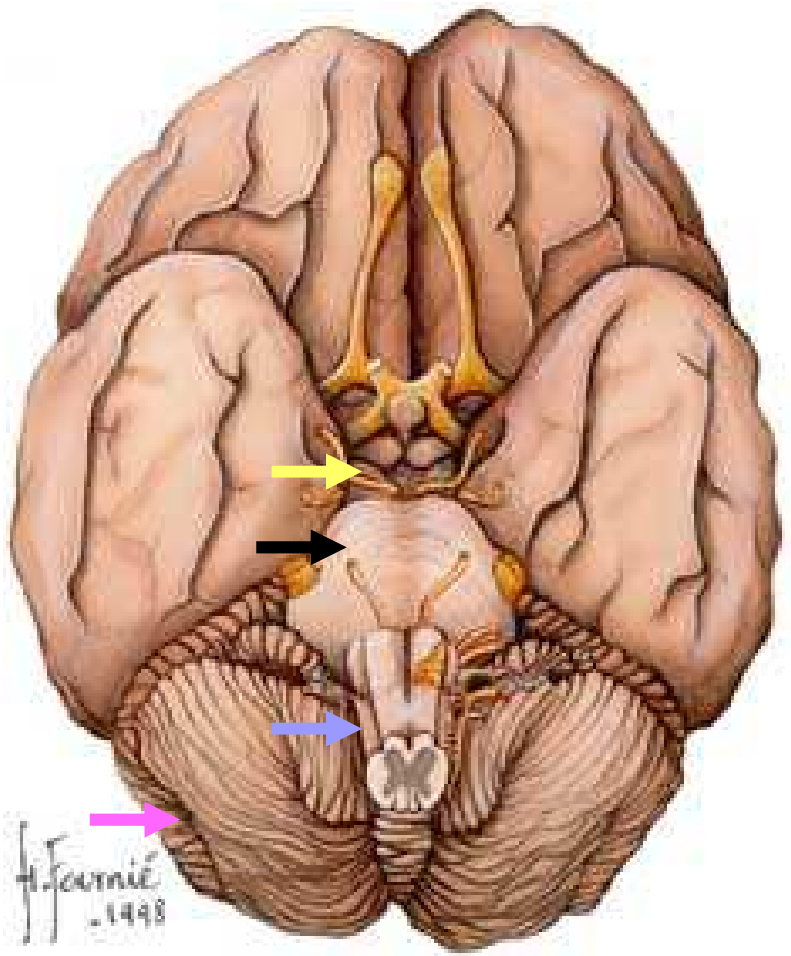
Vue antérieure

Tronc cérébral : 3 étages

- Moelle allongée (bulbe rachidien)
- Pont (protubérance annulaire)
- Mésencéphale
- Cervelet en arrière



Vue antérieure du tronc cérébral

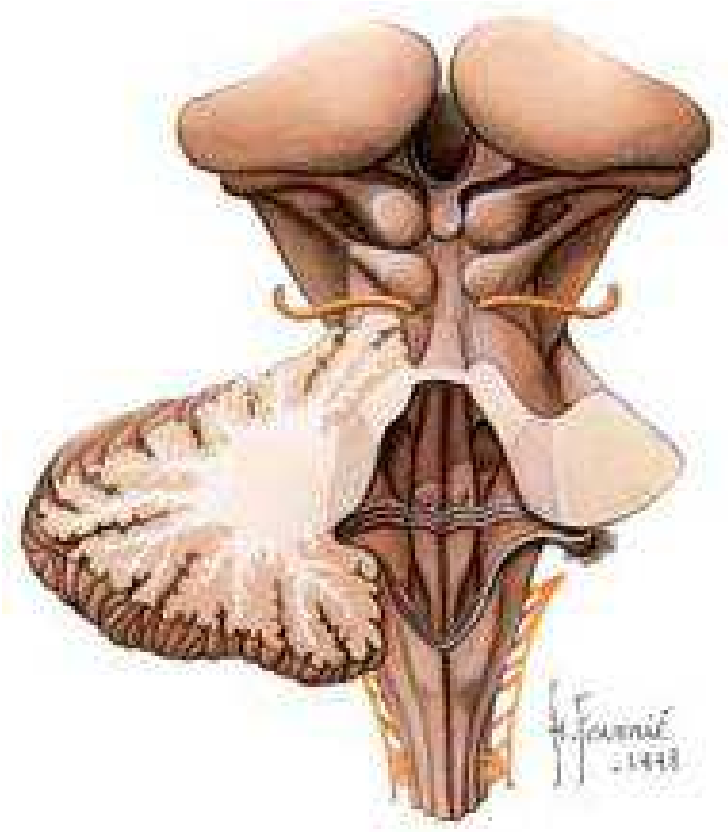


Vue inférieure du cerveau

Face postérieure et V4

- colliculus inférieurs
- Bras conjonctival inférieur
- Corps géniculé médial
- colliculus supérieurs
- BCS, CGLatéral
- frein du voile médullaire supérieur
- nerf trochléaire

Coupe sagittale

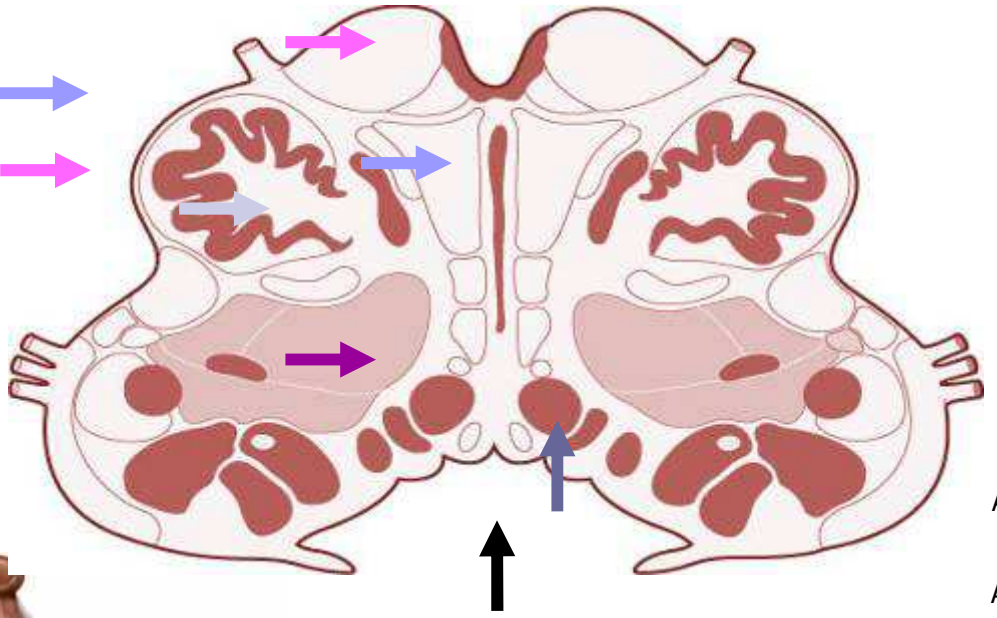


H
B

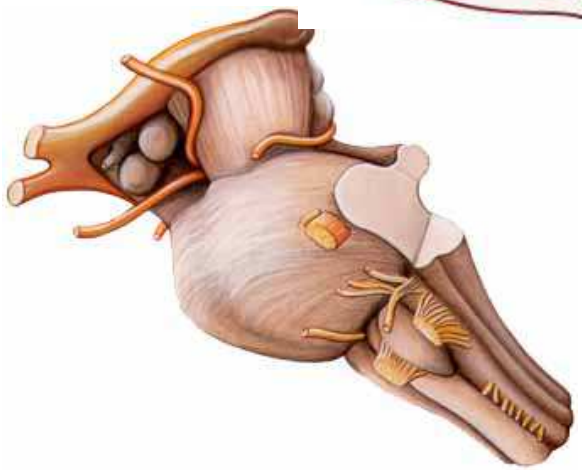
vue postérieure du TC

Tronc cérébral : contenu

- Voies ascendantes (sensibilité)
- Voies descendantes (motricité)
- noyaux des nerfs crâniens
- noyaux propres
- substance réticulée
- Cavité épendymaire
  - Quatrième ventricule.



Coupe axiale de la moelle allongée



Cortex cérébral

Bases anatomiques des grandes régions fonctionnelles corticales

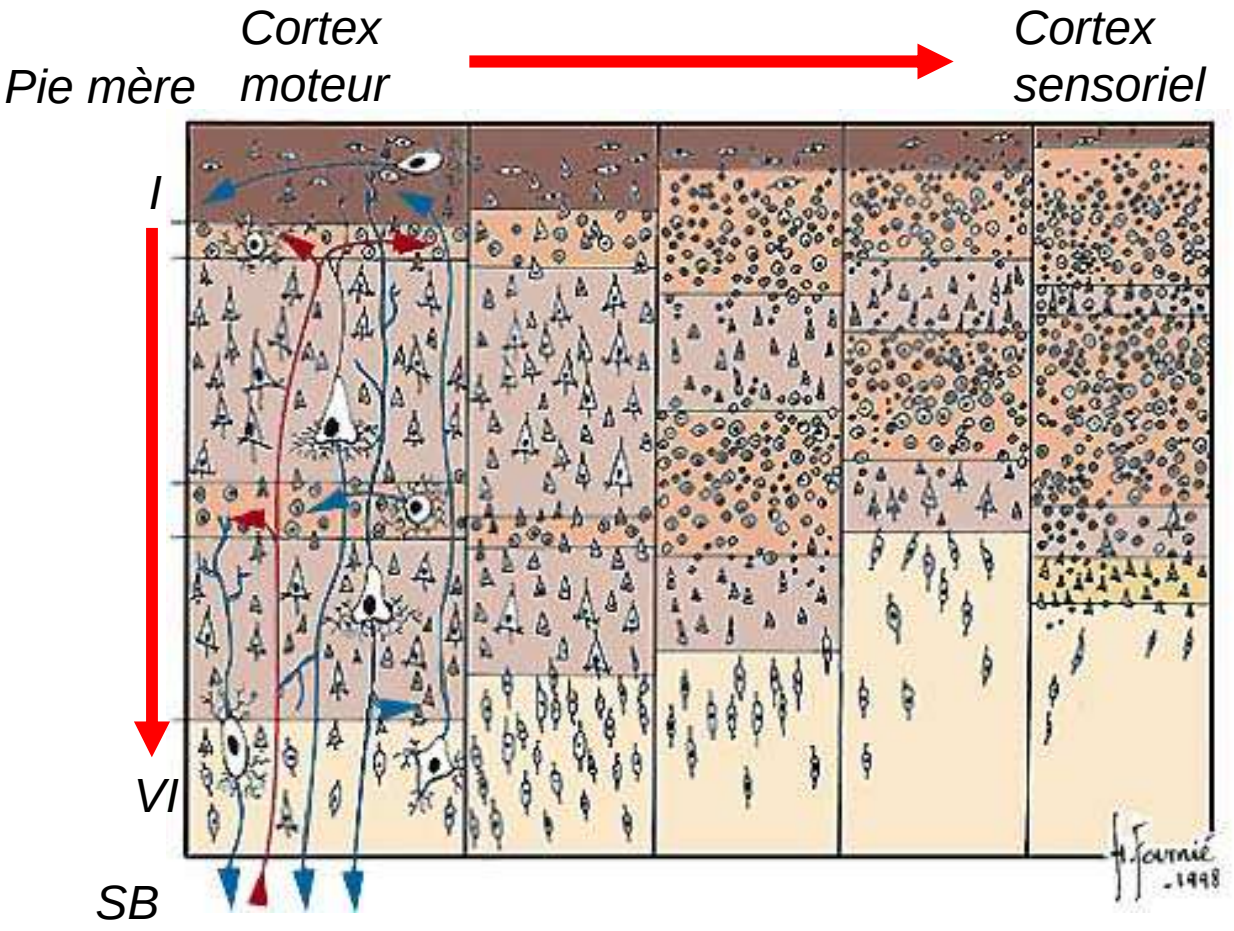
UNIVERSITE PIERRE & MARIE CURIE
CHU-PS Pitié - Salpêtrière

Néocortex : Histologie

- Granulaire : réception
- Pyramidal : effecteur

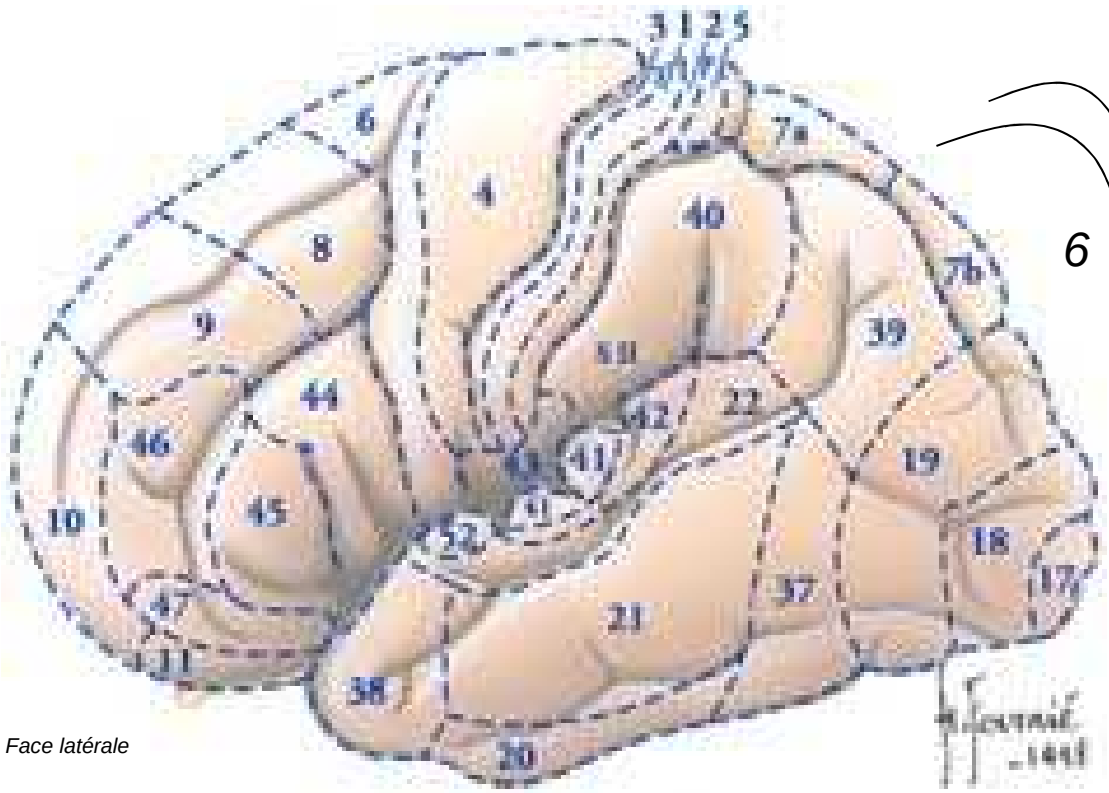
- Profond : à distance
- Superficiel : régional

- I : moléculaire
- II : granulaire externe
- III : pyramidale externe
- IV : granulaire interne
- V : pyramidale interne
- VI : fusiforme polymorphe



Différents types de cortex : histologie

Aires de Brodmann

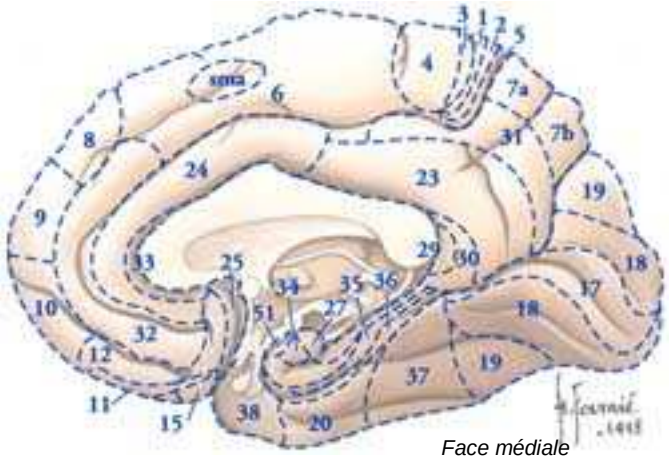


Face latérale

cytoarchitectonie

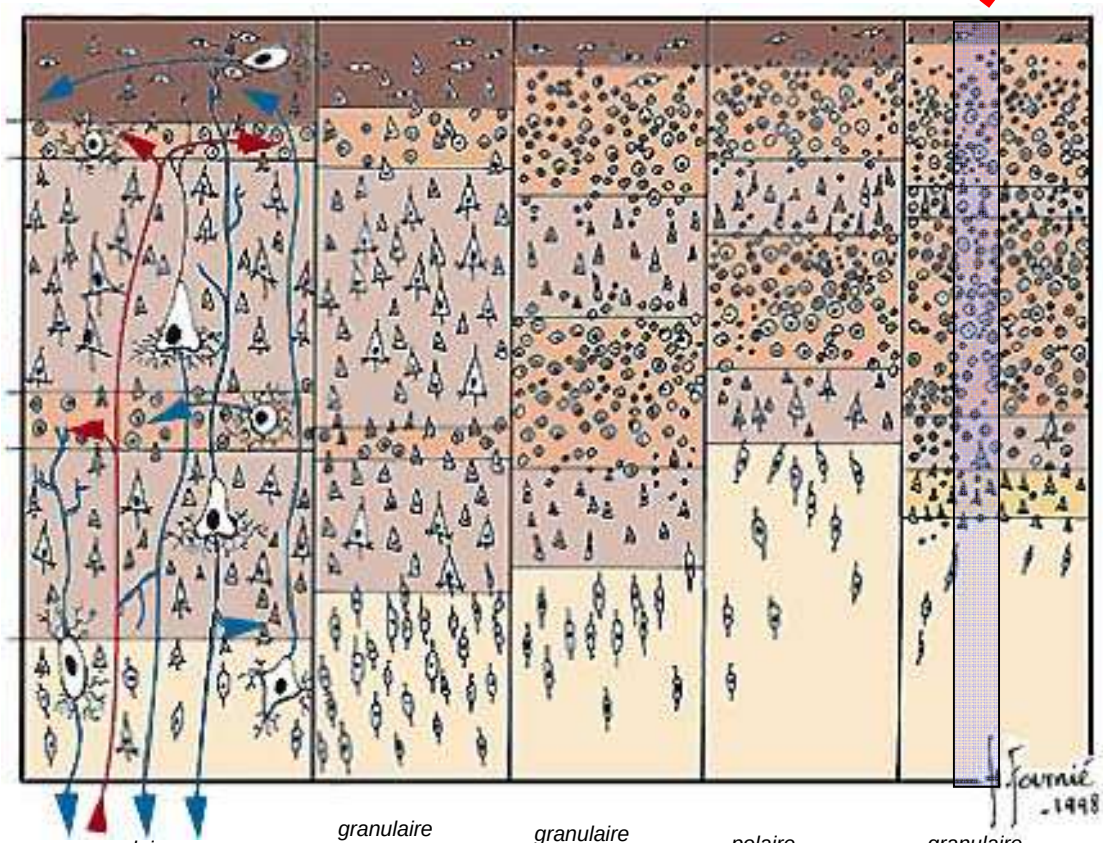
6

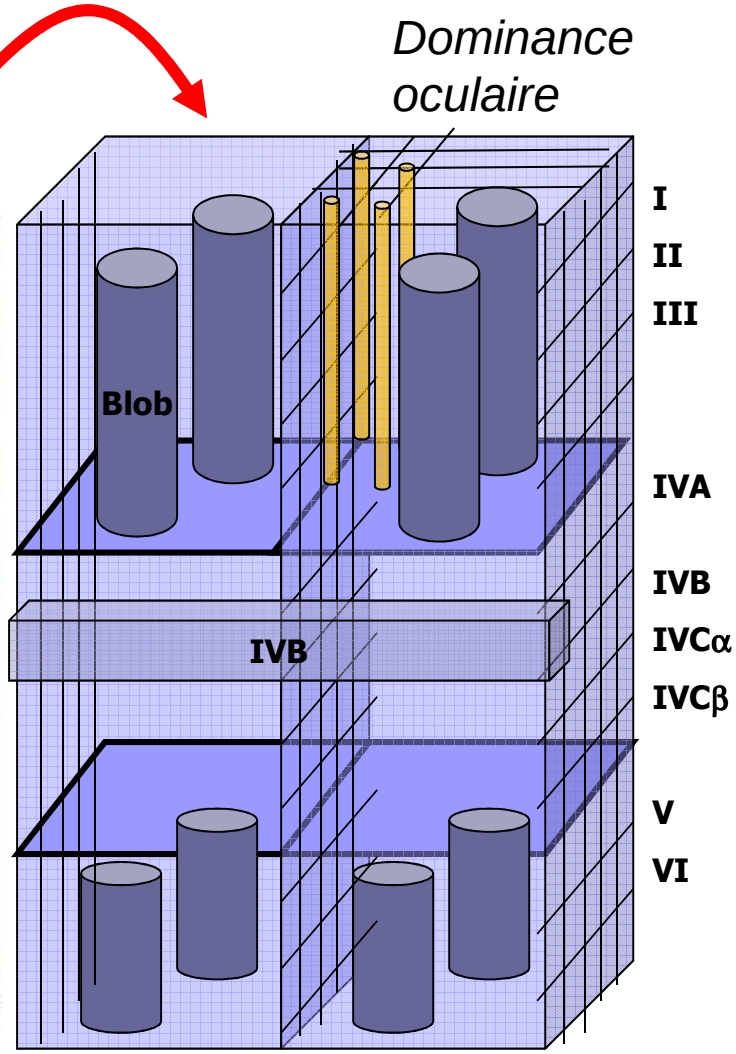
4



Face médiale

Cortex : colonnes

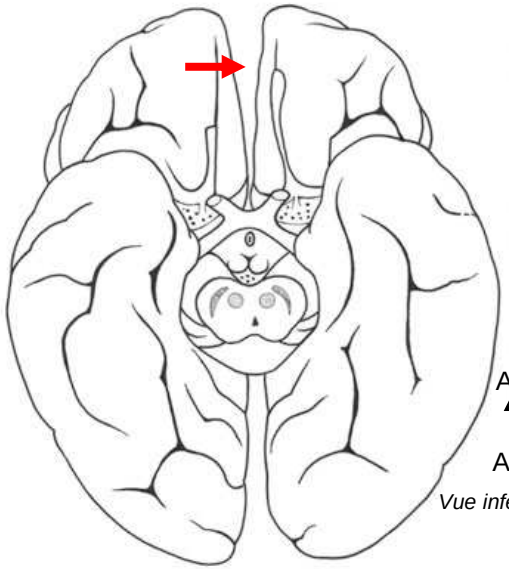


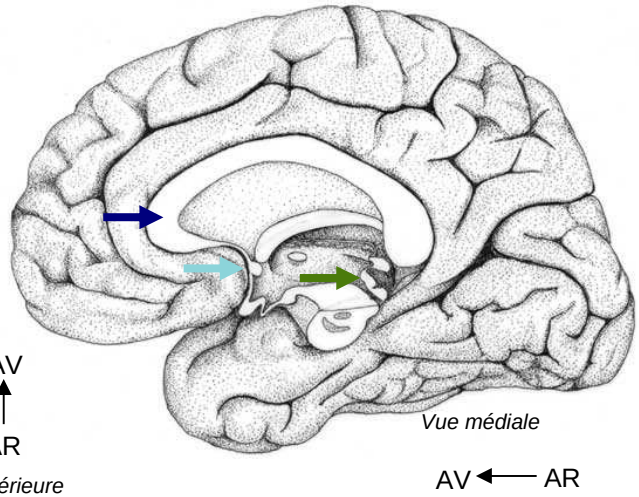


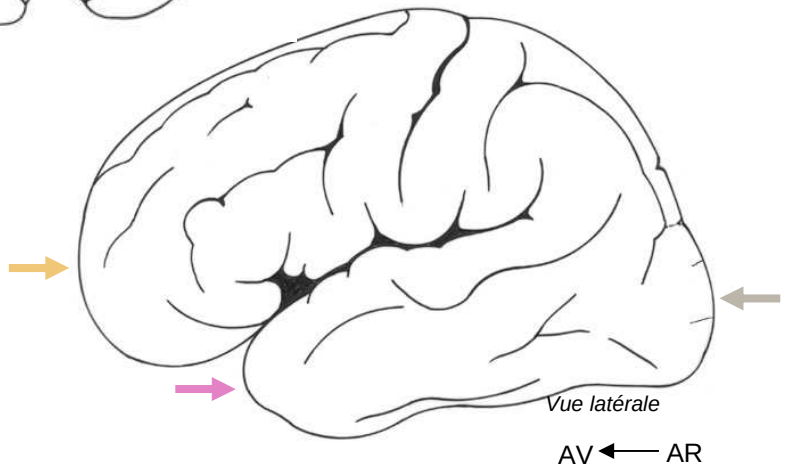
2 colonnes du cortex visuel

Anatomie : Faces et pôles

- 2 hémisphères
- Fissure longitudinale →
- Commissures
  - Corps calleux →
  - Commissure antérieure →
  - Commissure postérieure →
- 3 Faces
  - Latérale
  - Inférieure
  - Face médiale
- 3 Pôles
  - Frontal →
  - Temporal →
  - Occipital →

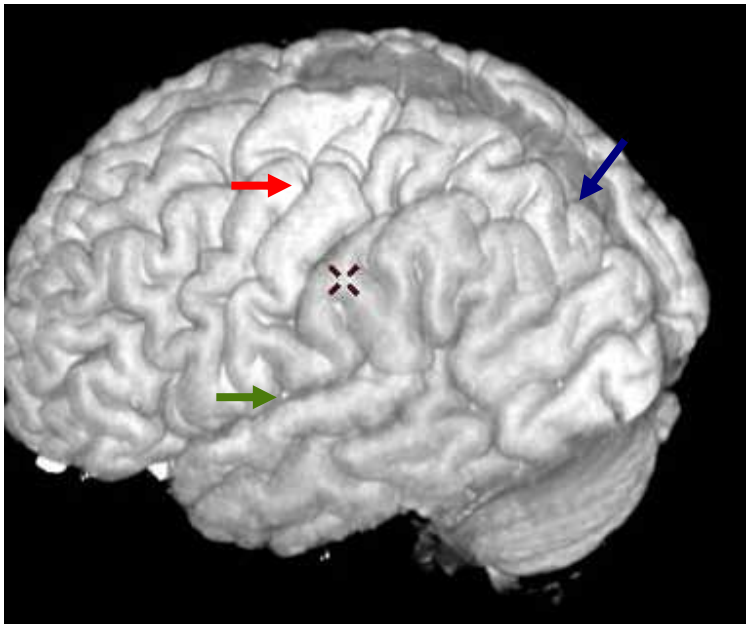


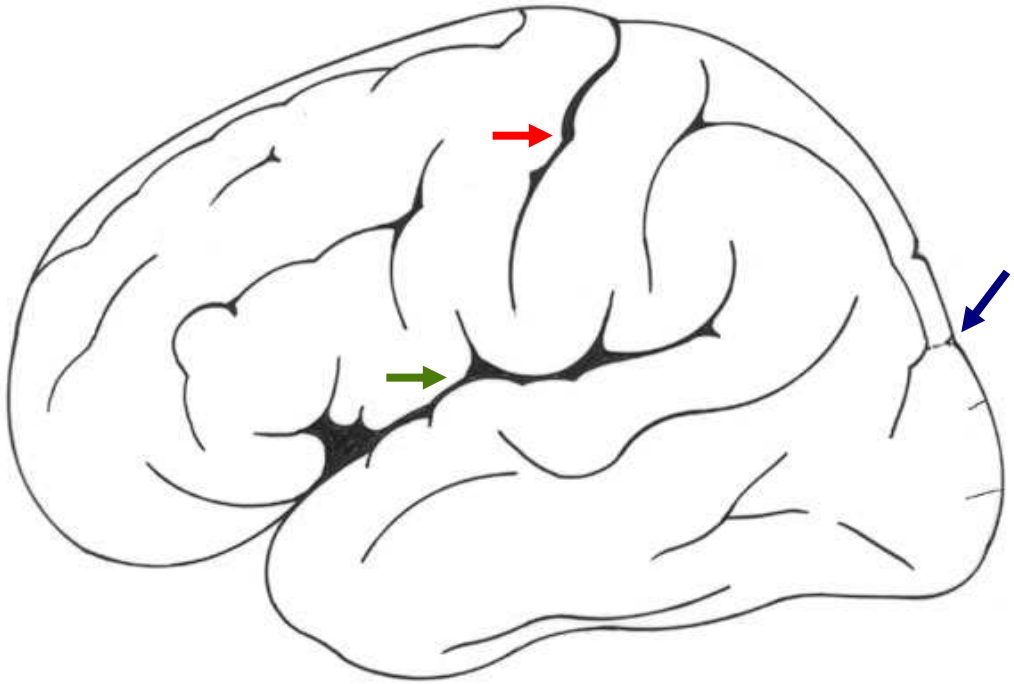




Face latérale : sillons et lobes

- Sillon latéral →
- Sillon central →
- Sillon Pariéto Occipital →

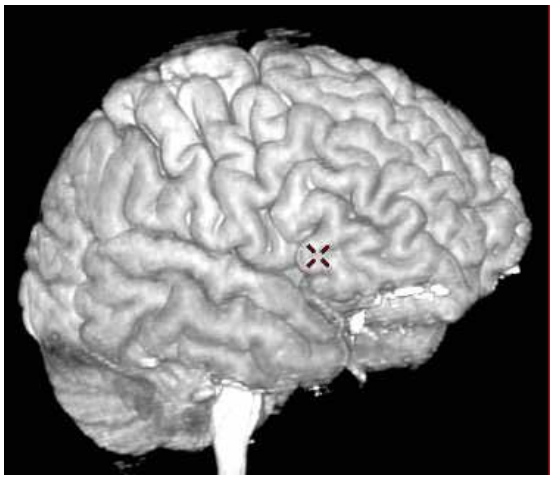




Vues latérales

F3 - Aire de Broca

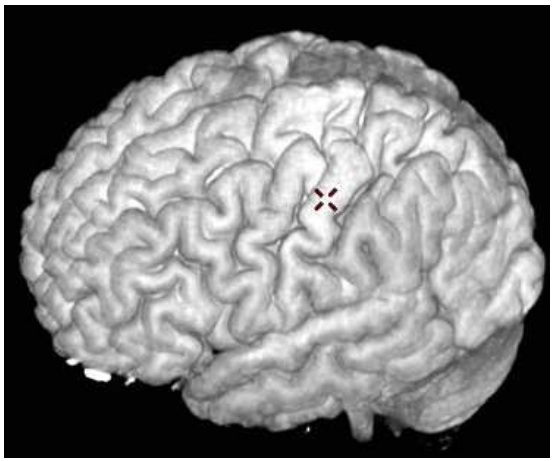
- Partie orbitaire →
- Partie triangulaire →
- Partie operculaire →
  - Aire de Broca

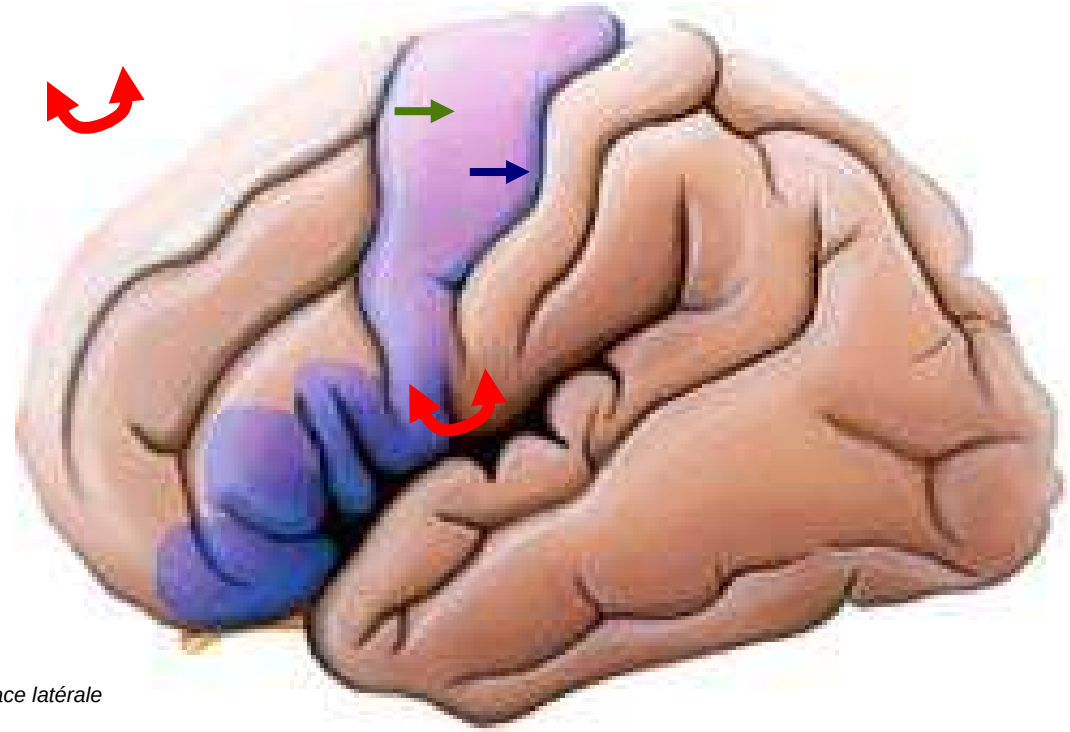


Face latérale

Gyrus Précentral : M_I

- Gyrus Précentral →
- Sillon central →
- Opercule rolandique



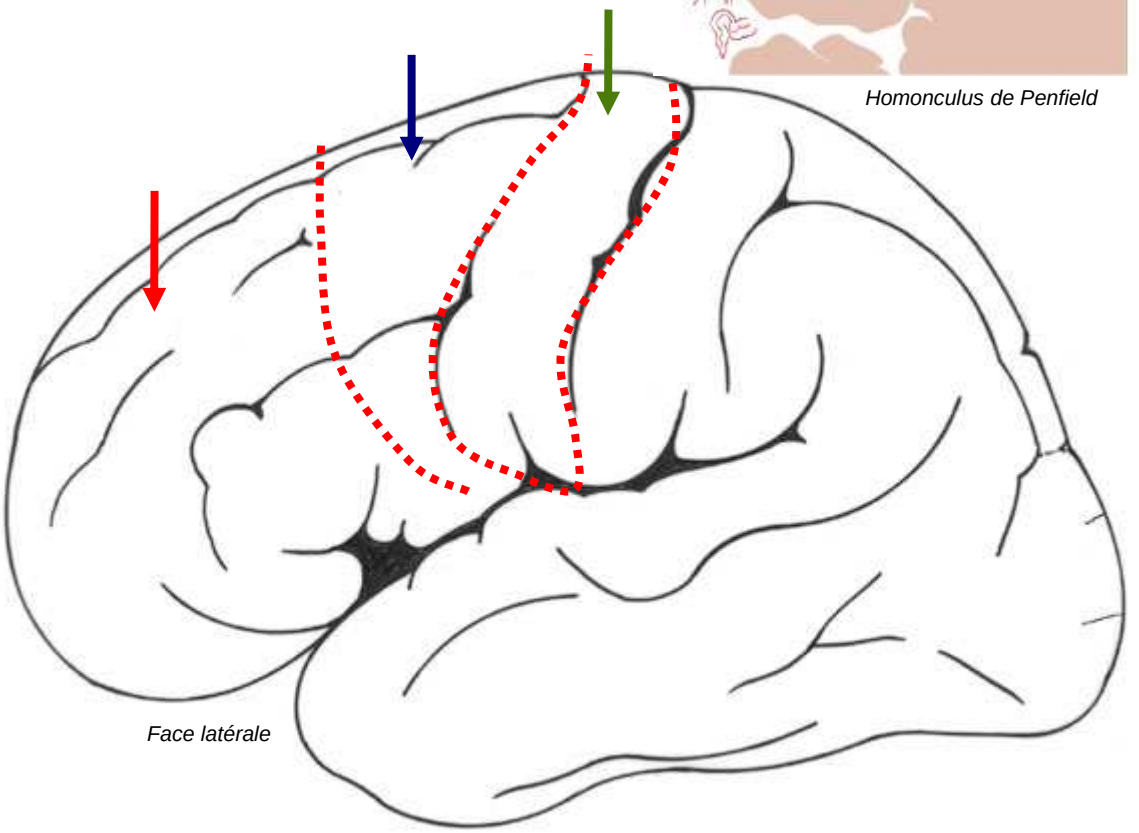


Face latérale

Régions frontales

- Motrice →
  - Primaire : M_I
  - Operculaire
- Prémotrice →
- Préfrontale → (cortex associatif)

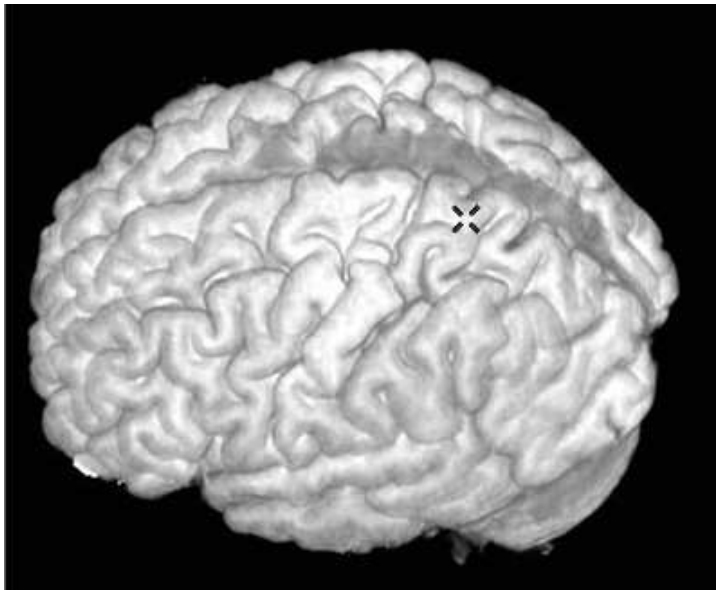
Homonculus de Penfield

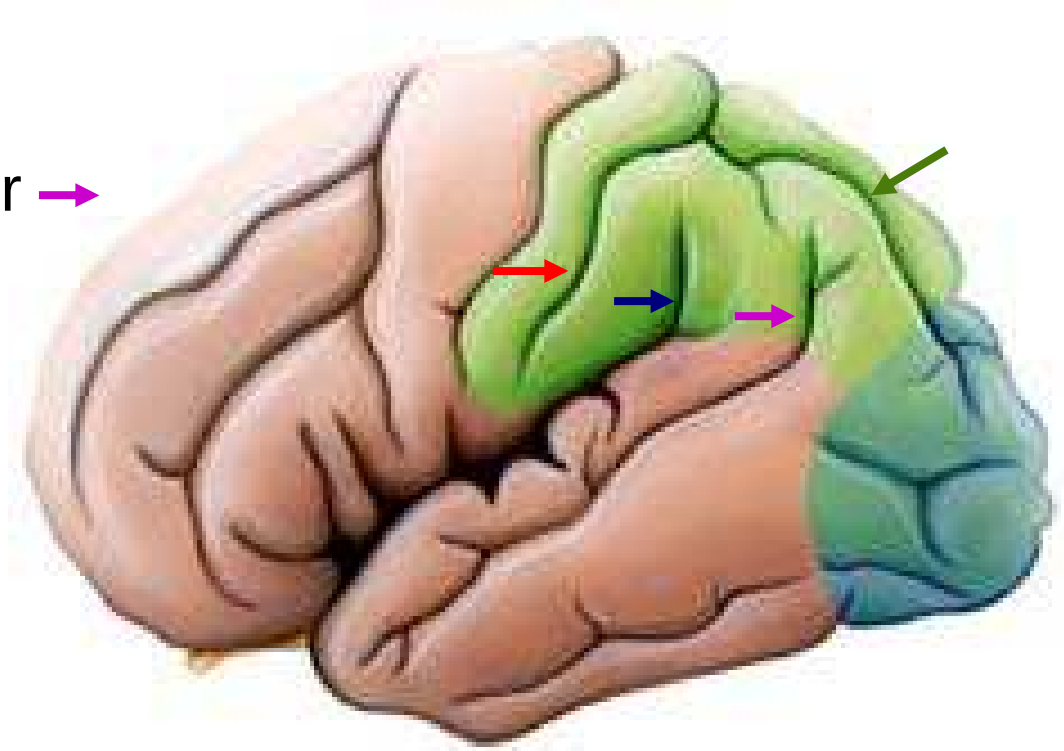


Face latérale

Lobe Pariétal

- Sillon postcentral →
- Sillon IntraPariétal →
- Sillon latéral →
- Sillon temporal supérieur →

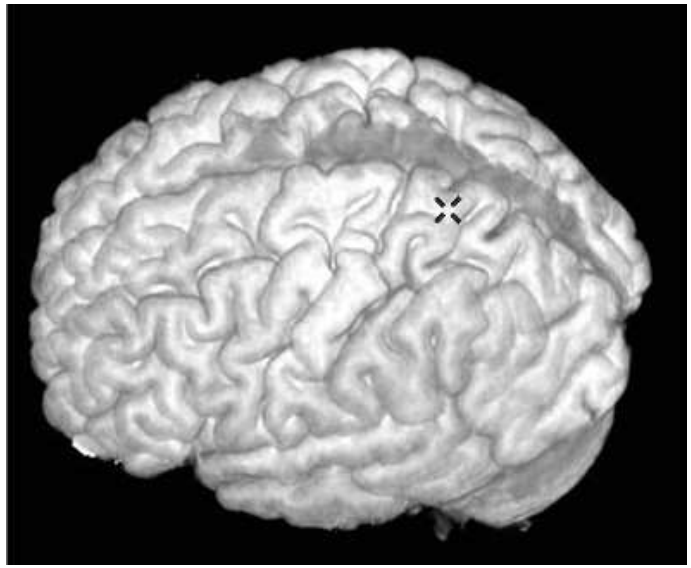




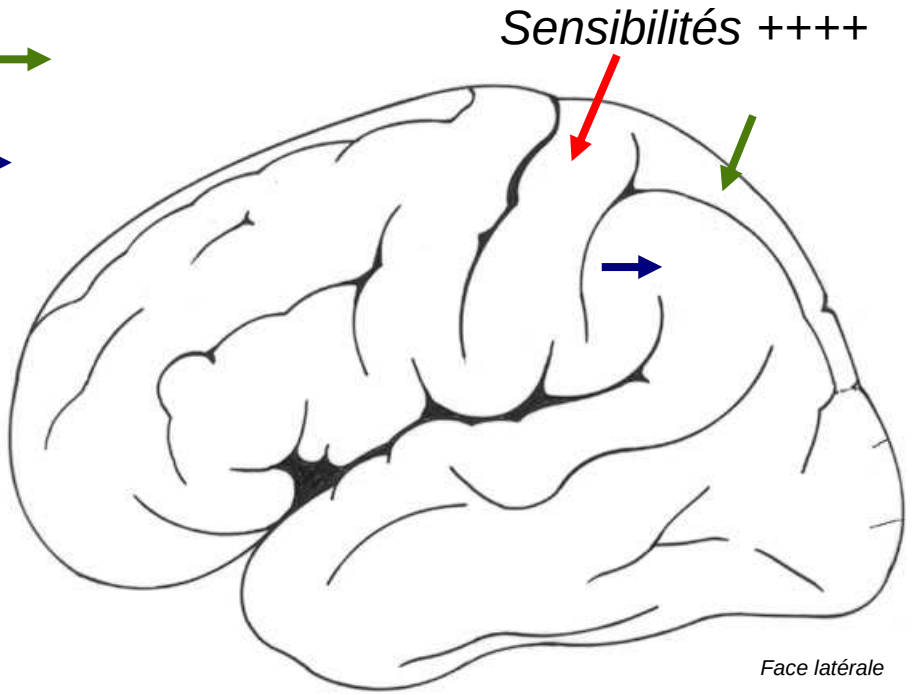
Face latérale

Lobe Pariétal

- Gyrus postcentral : S_I →
- Gyrus pariétal supérieur →
- Gyrus pariétal inférieur →



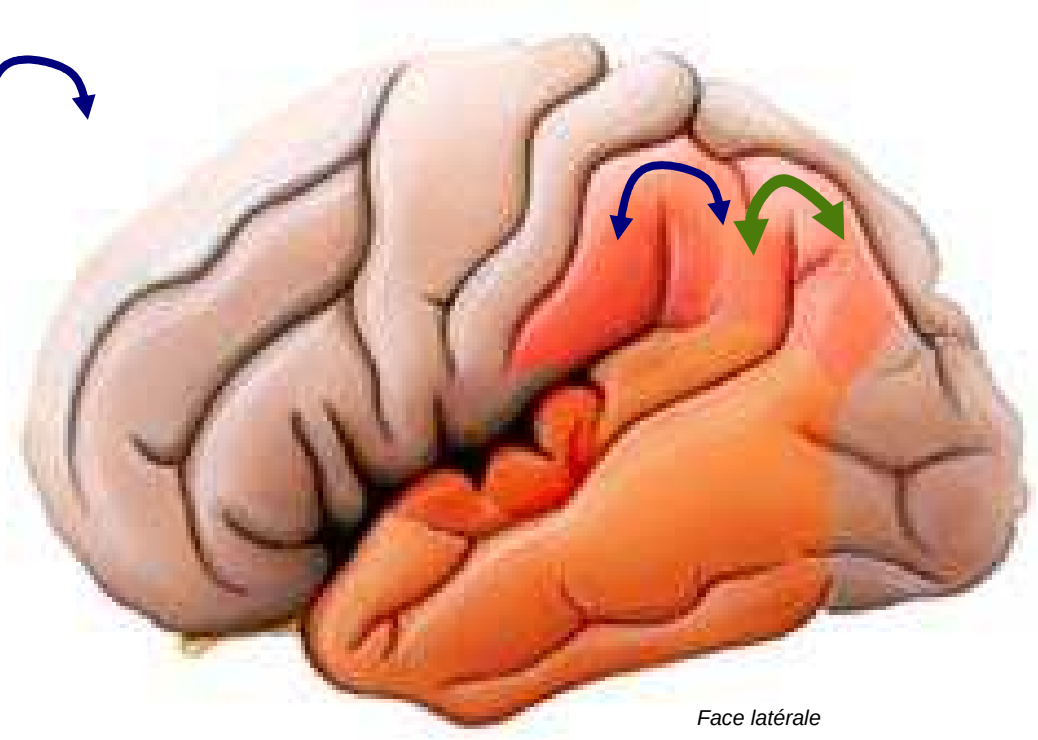
Face latérale supérieure gauche



Face latérale

Carrefour TPO

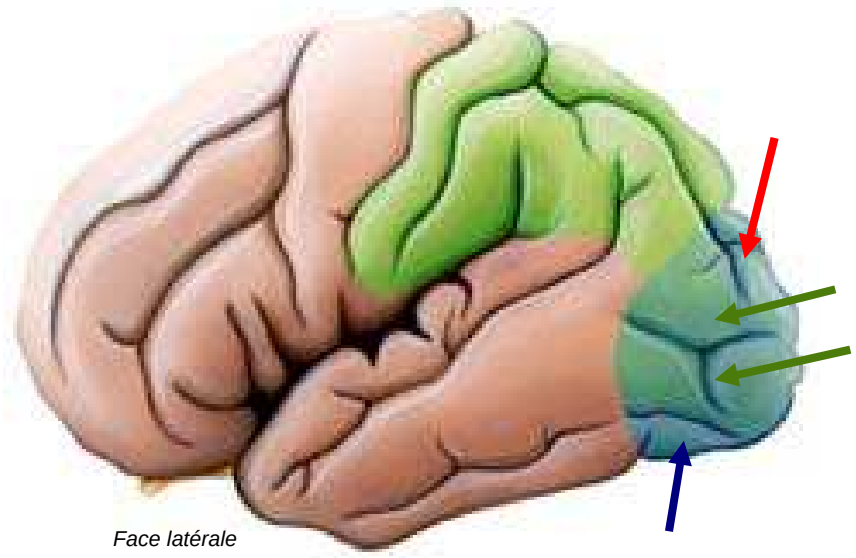
- Gyrus supramarginal
(lobule pli curbe)
- Gyrus angulaire
(lobule pli curbe)
- Cortex associatif



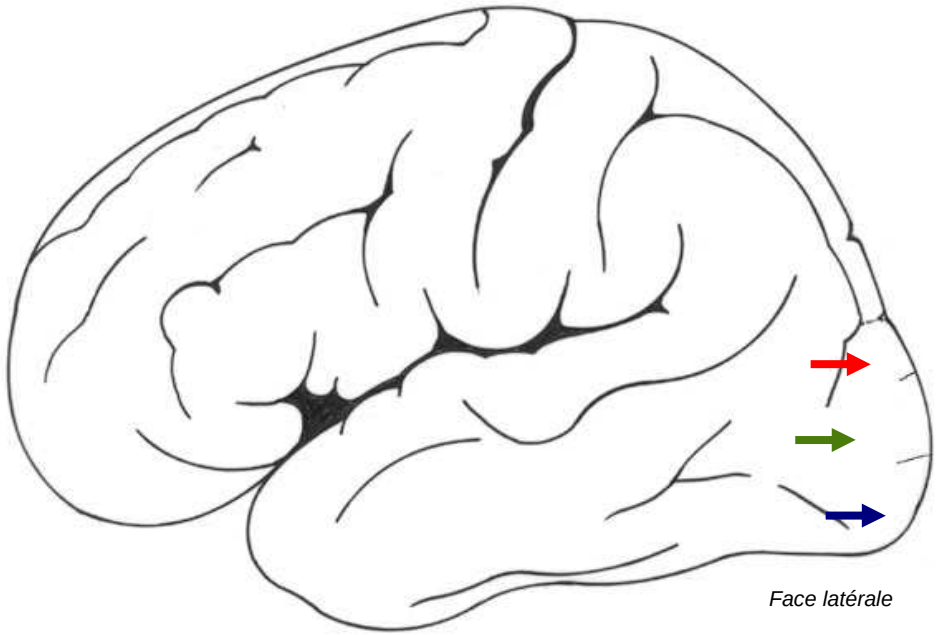
Face latérale

Occipital

- O1 →
- O2 →
- O3 →
- Continuité T-O et P-O



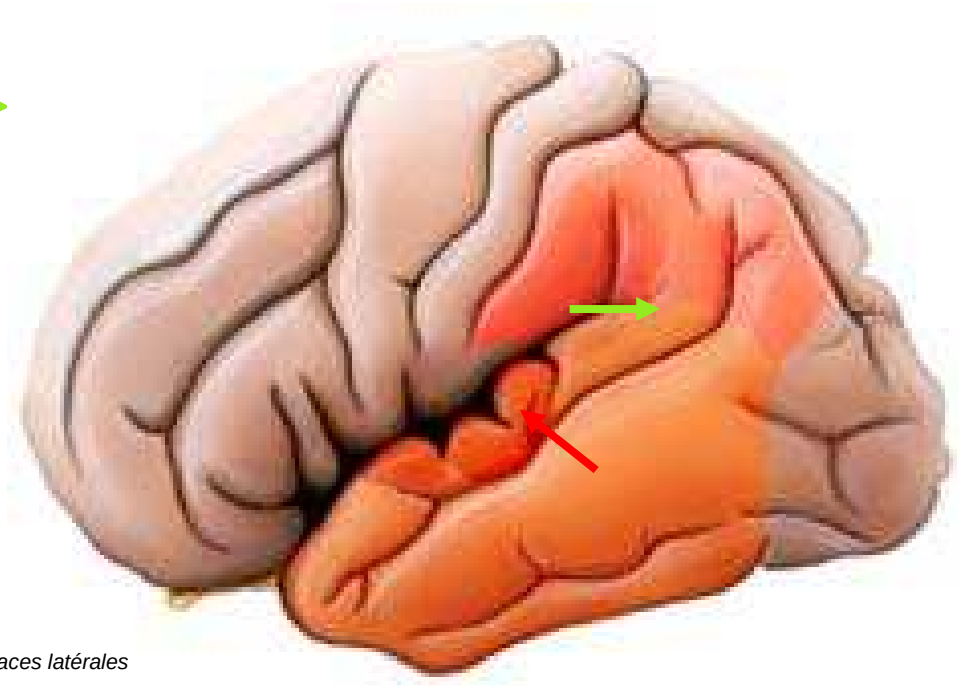
Face latérale



Face latérale

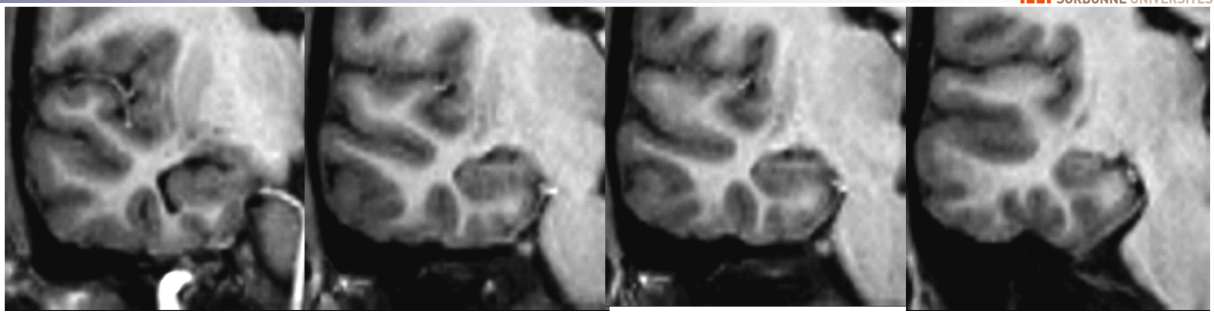
Lobe temporal

- T1 – T3
- Gyrus de Heschl →
- Aire de Wernicke →

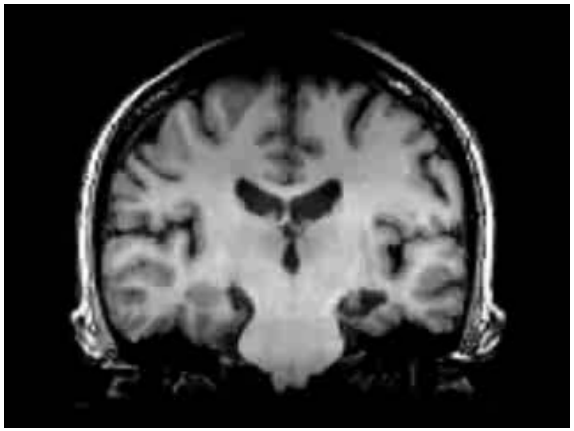


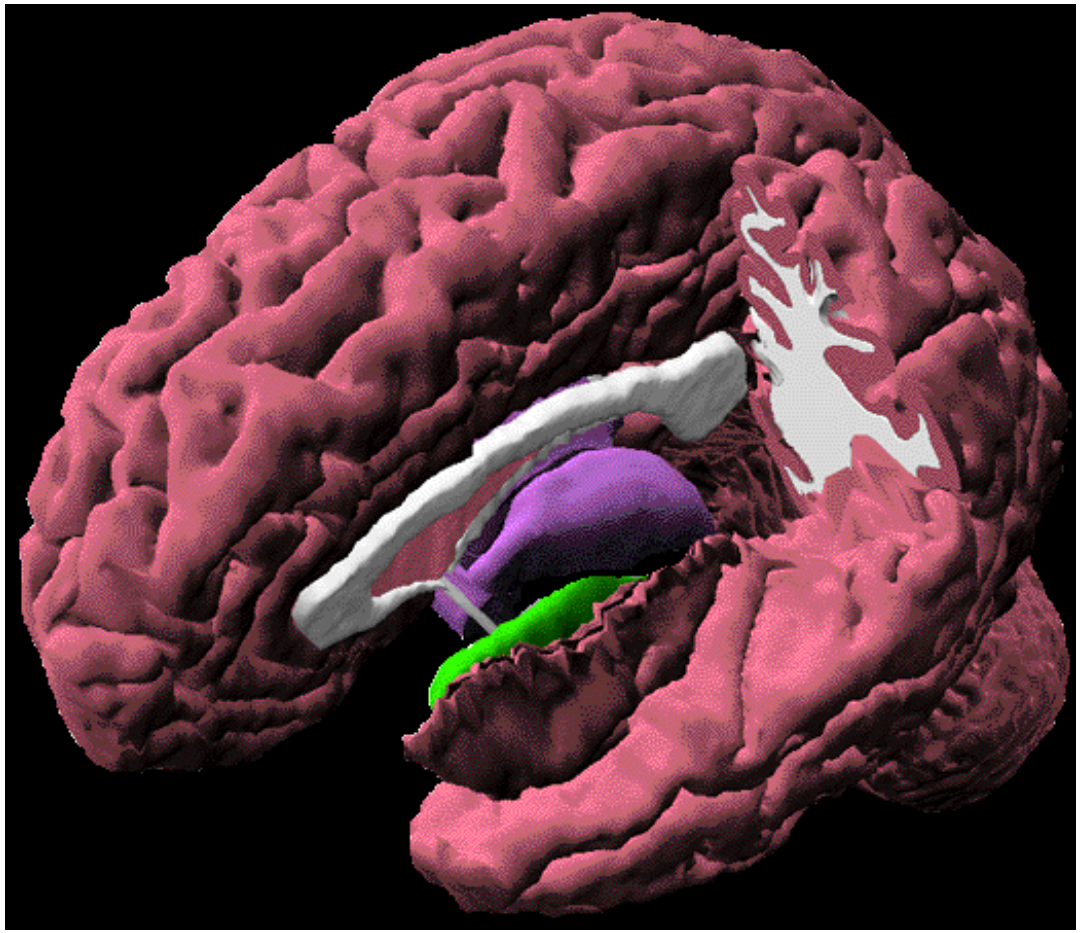
Faces latérales

Audition



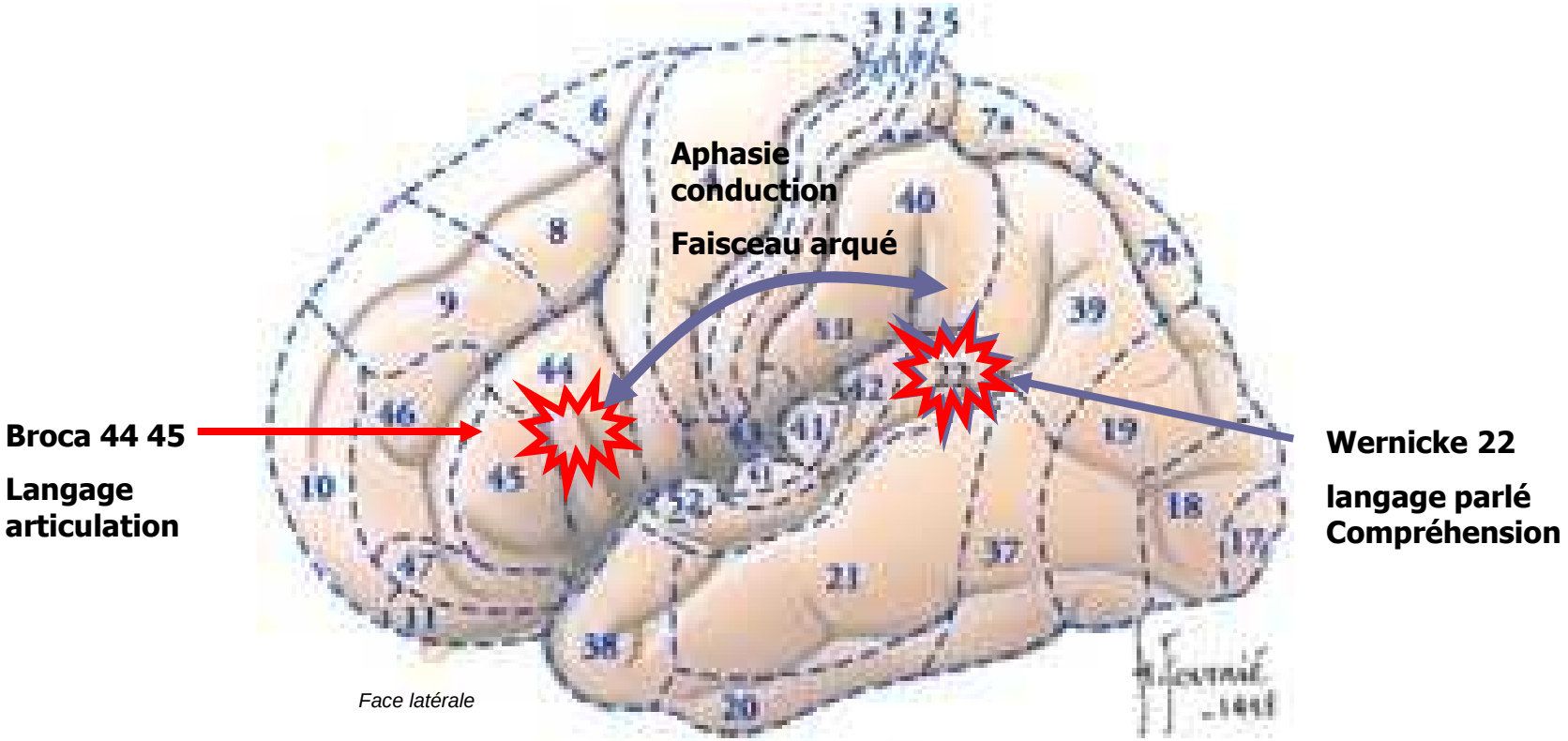
- Sillon temporal transverse intermédiaire
- Gyrus temporal transverse antérieur et postérieur
- Aire auditive I (aire 41)
- Tonotopie





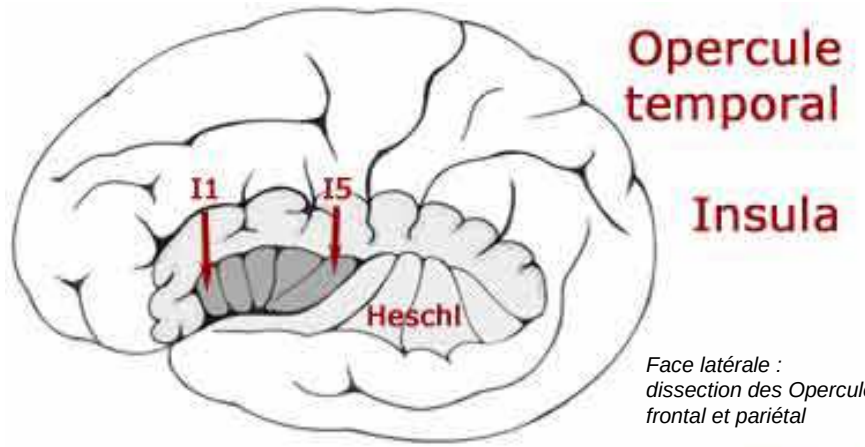
Langage

- aphasies

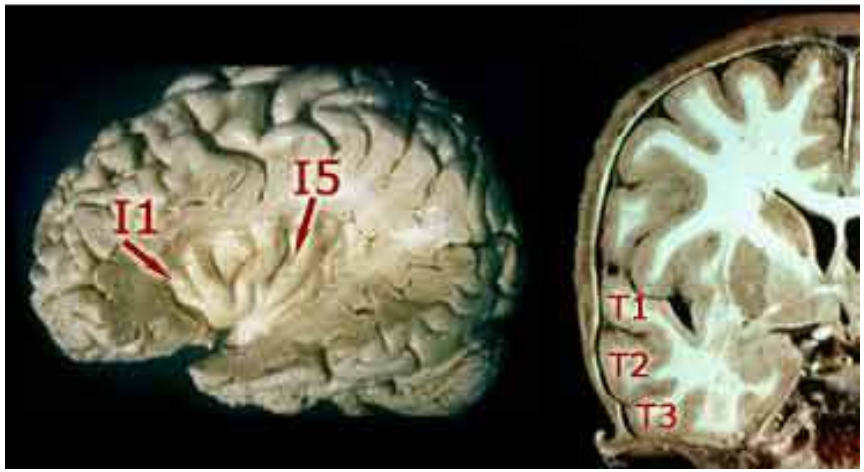


Insula

- Fond du sillon latéral
- 5 gyri
- Végétatives
- Voies douleur Insula antérieure



Face latérale : dissection des Opercules frontal et pariétal



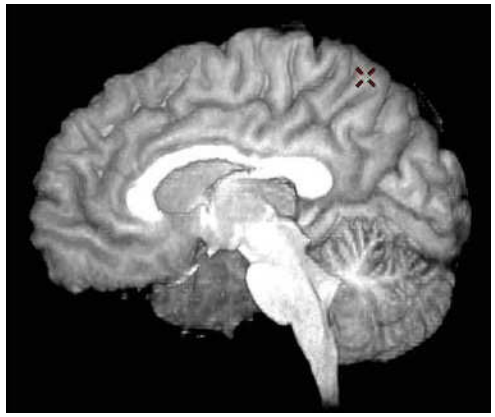
Face latérale : dissection de l'insula

Coupe coronale

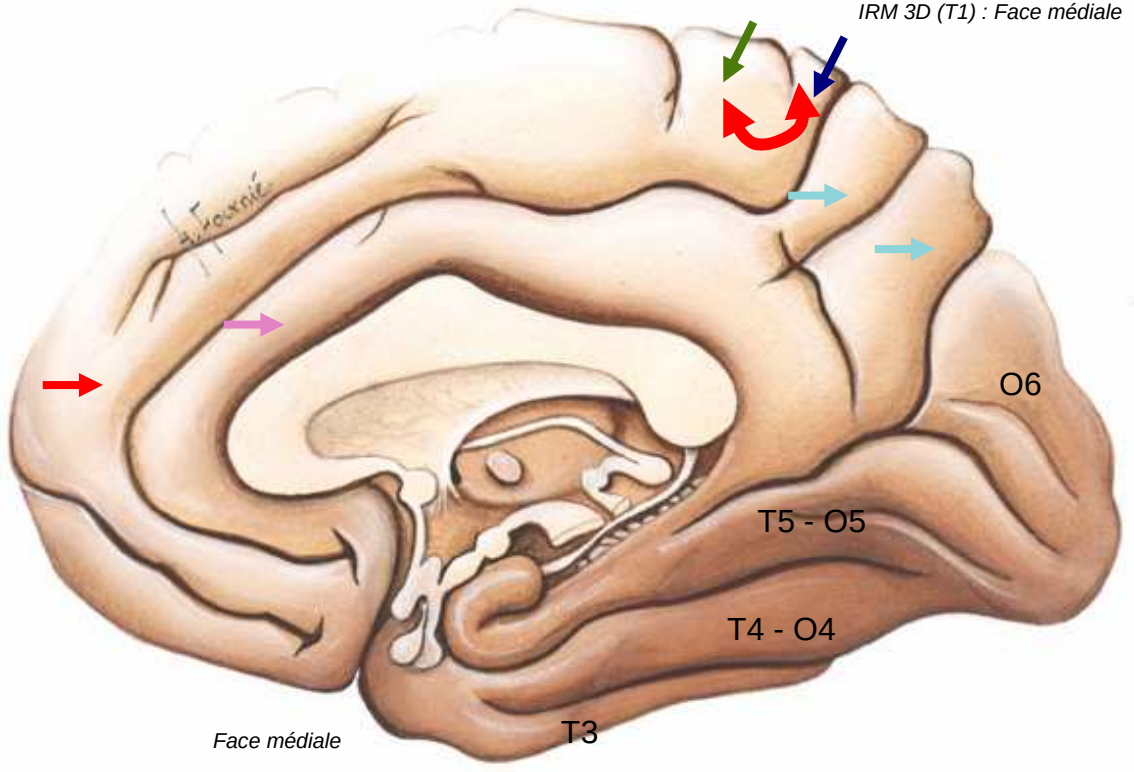
Face médiale

Face médiale : gyri

- Frontal
  - F1
  - Gyrus précentral
  - Lobule paracentral
- Pariétal
  - Gyrus postcentral
  - Précunéus
- Gyrus cingulaire
- Occipital
  - Cunéus O6 (aire 17)
  - Gyrus lingual : O5
  - Gyrus fusiforme : O4
  - O3
- Temporal
  - T5, T4, T3



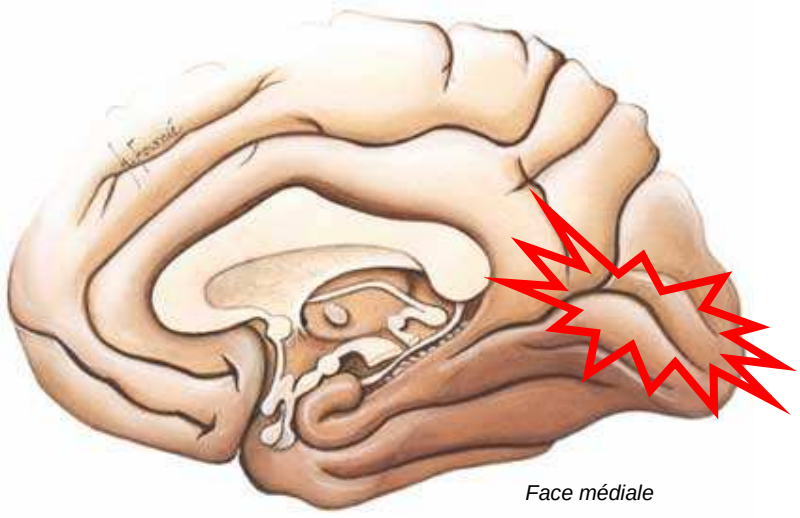
IRM 3D (T1) : Face médiale



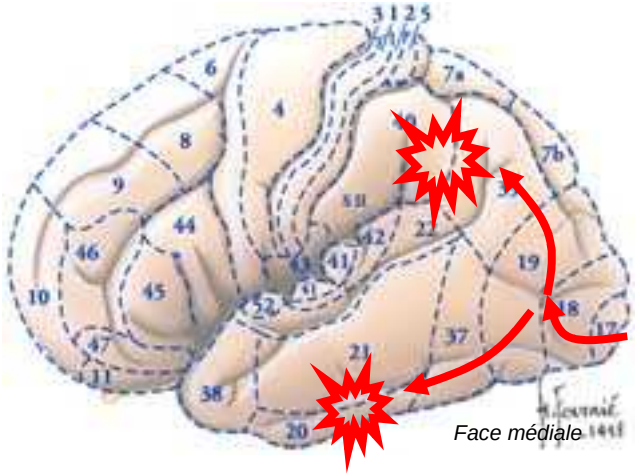
Face médiale

Occipital : vision

- V1 : aire 17
  - Radiations optiques
  - rétinotopie
- Lésion unilatérale
  - hémianopsie latérale homonyme
  - quadranopsie
- bilatérale
  - cécité corticale conserve les réflexes pupillaires
- agnosies
  - Agnosie visuelle
    - Objets, images, couleurs
- Crises visuelles

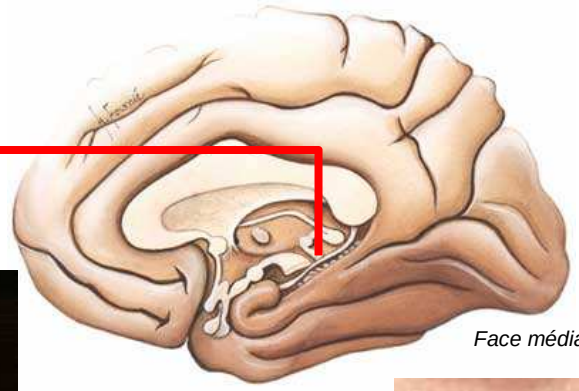


Face médiale

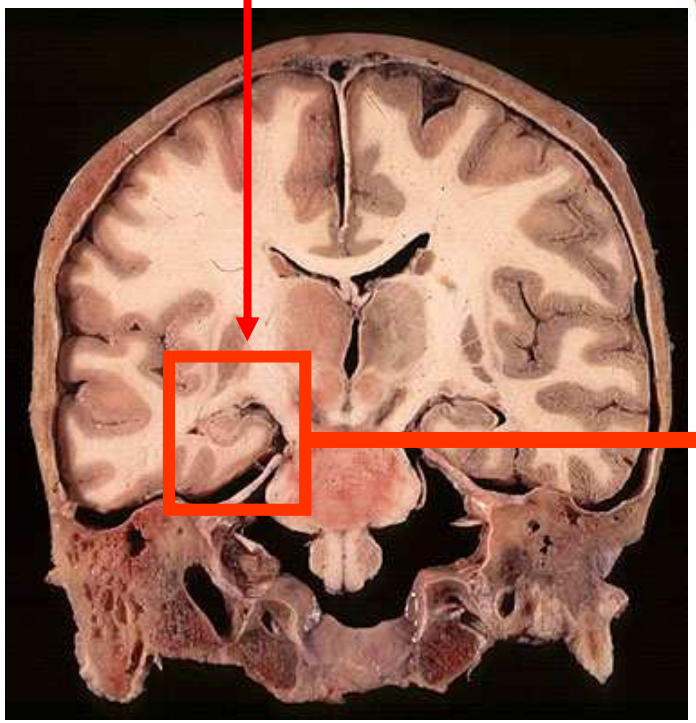


Face médiale

Temporal : Hippocampe

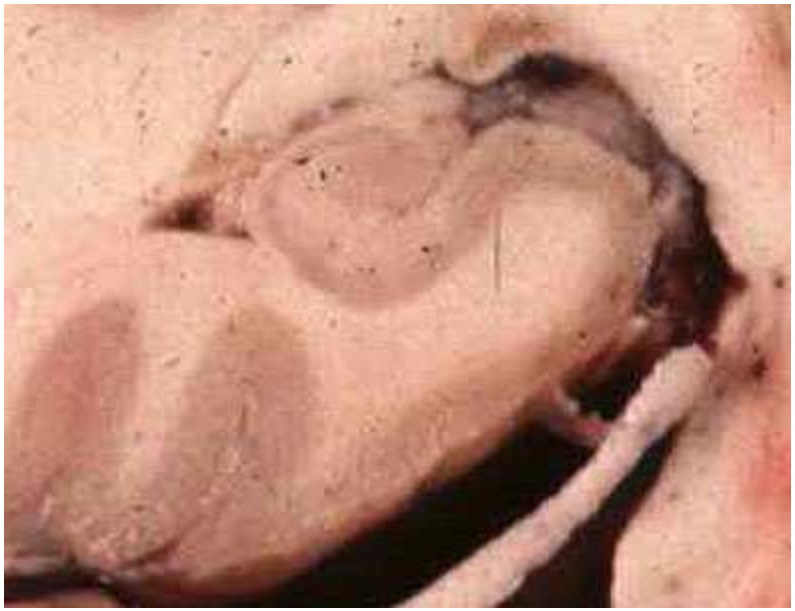


Face médiale



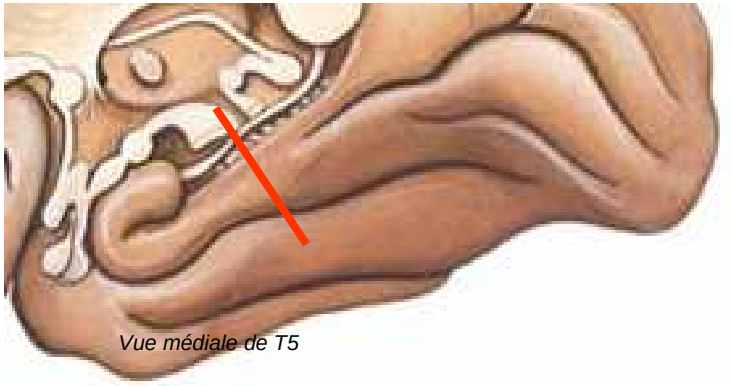
H
B

Coupes coronales

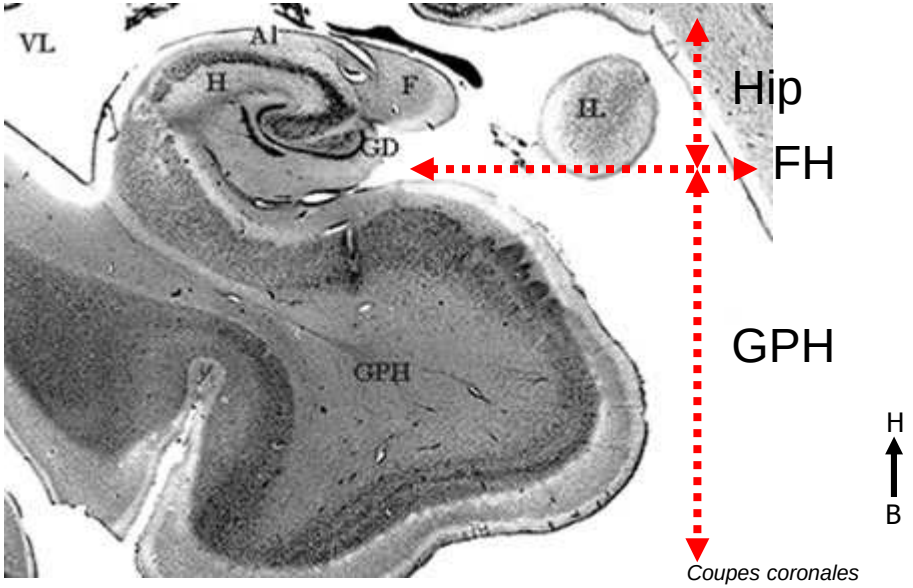


T5 : 2 étages

- Fissure hippocampique (FH)
  - Hippocampe (Hip)
  - Gyrus ParaHippocampique (GPH)
- Transition : région subiculaire



Vue médiale de T5



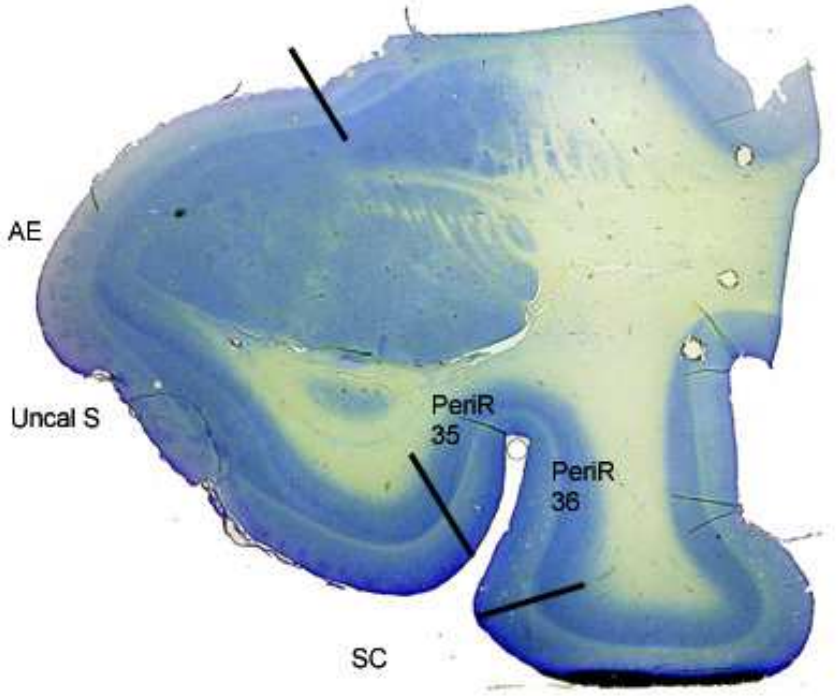
Coupes coronales

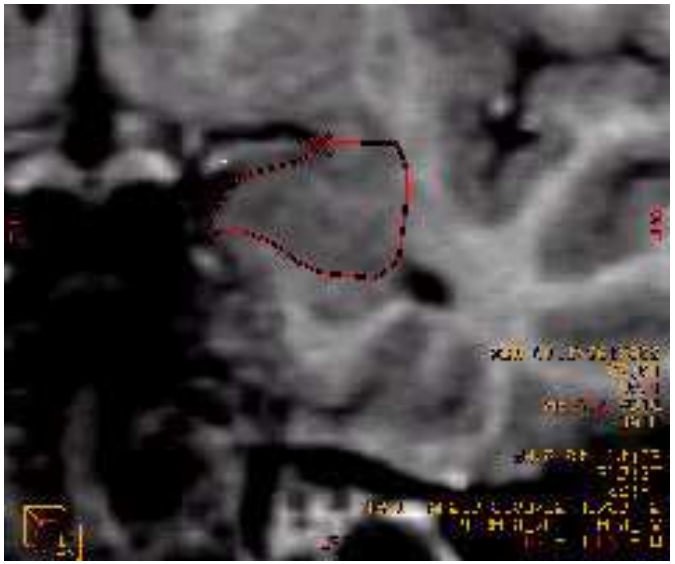
Histologie : coloration cellulaire de l'hippocampe

IRM T1 : Zoom centré sur l'hippocampe

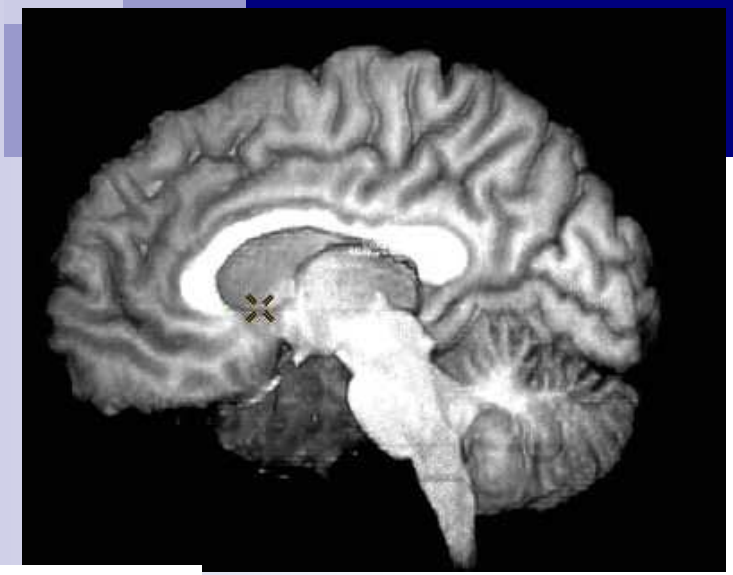
Amygdale

- Stimulation
  - Homme : peur, crises olfactives
  - Animal : éveil, automatismes, cpt défense attaque
- Destruction
  - encodage des attributs émotionnels : identification du danger

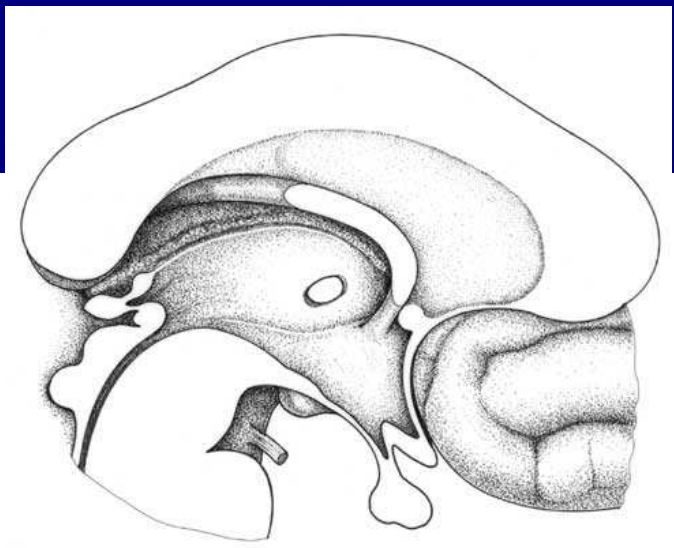




Diencéphale : V3



IRM 3D (T1) : coupe sagittale

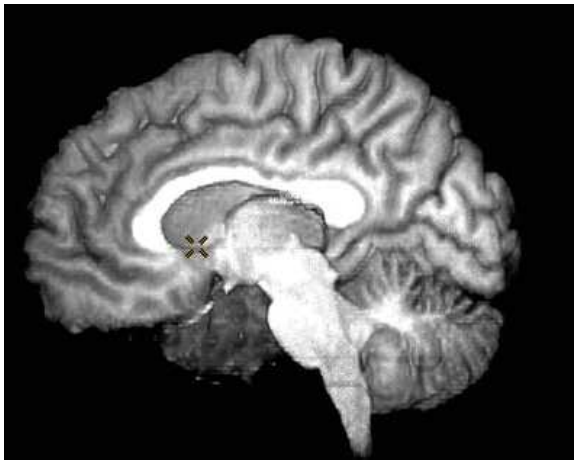


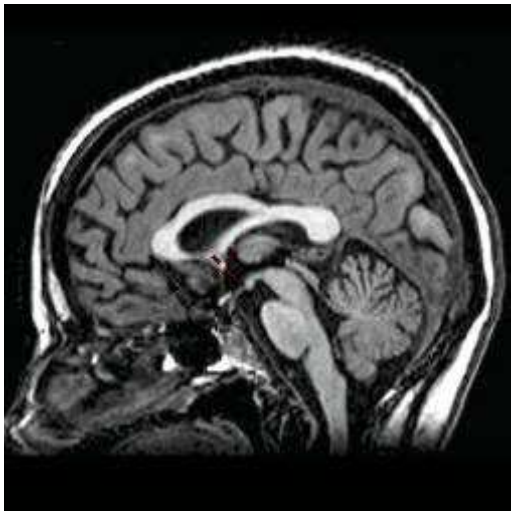
Coupe sagittale

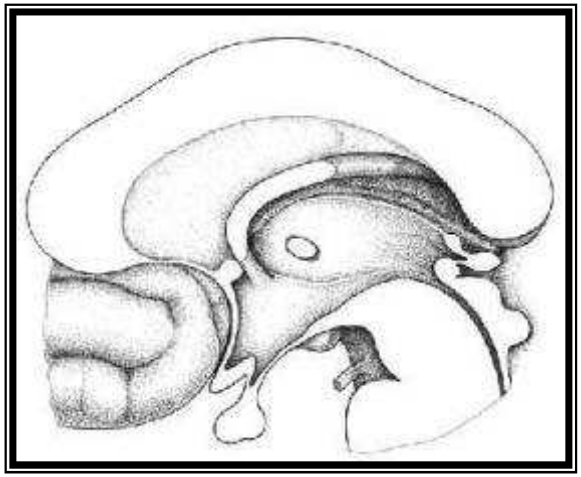
UNIVERSITE PIERRE & MARIE CURIE

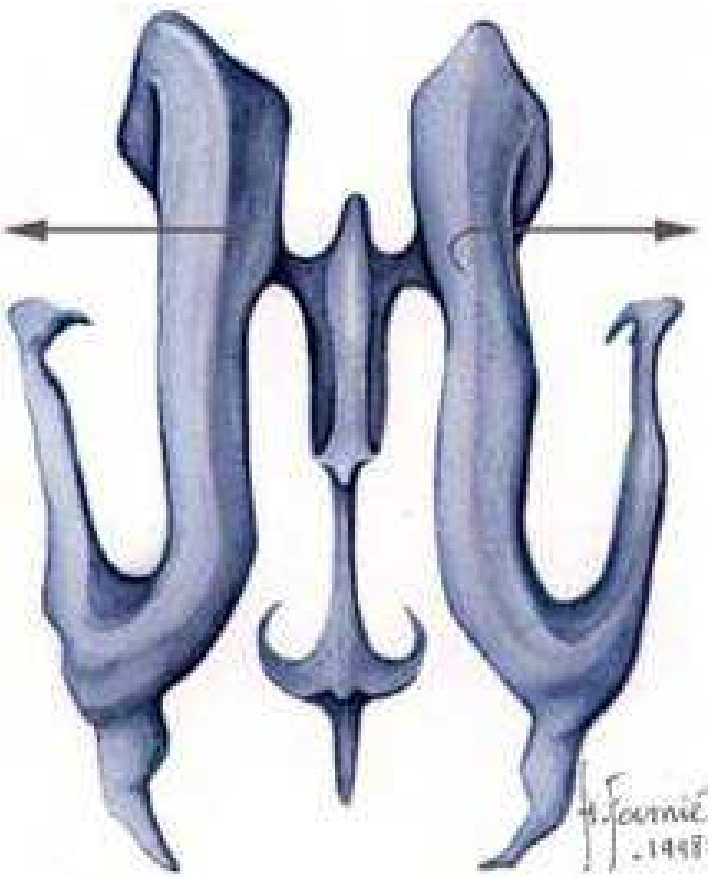
CHU-PS Pitié - Salpêtrière

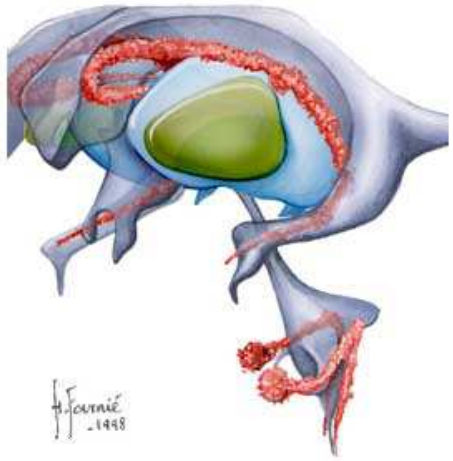
Ventricules





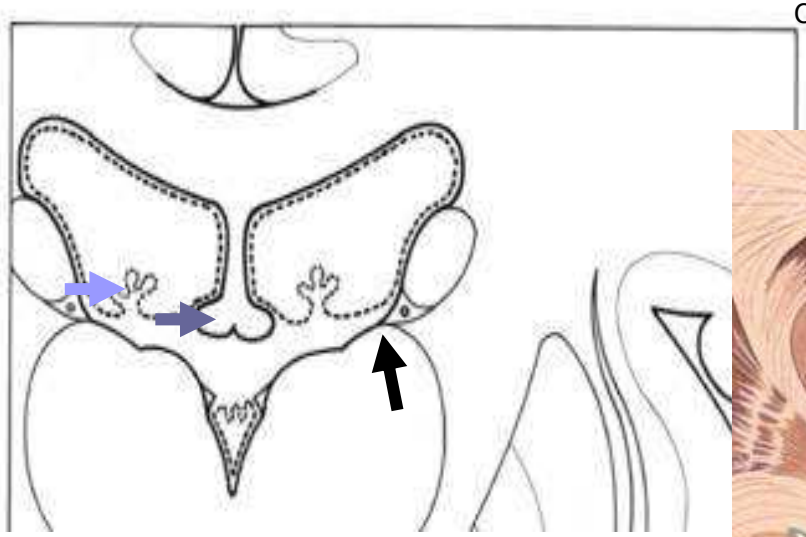




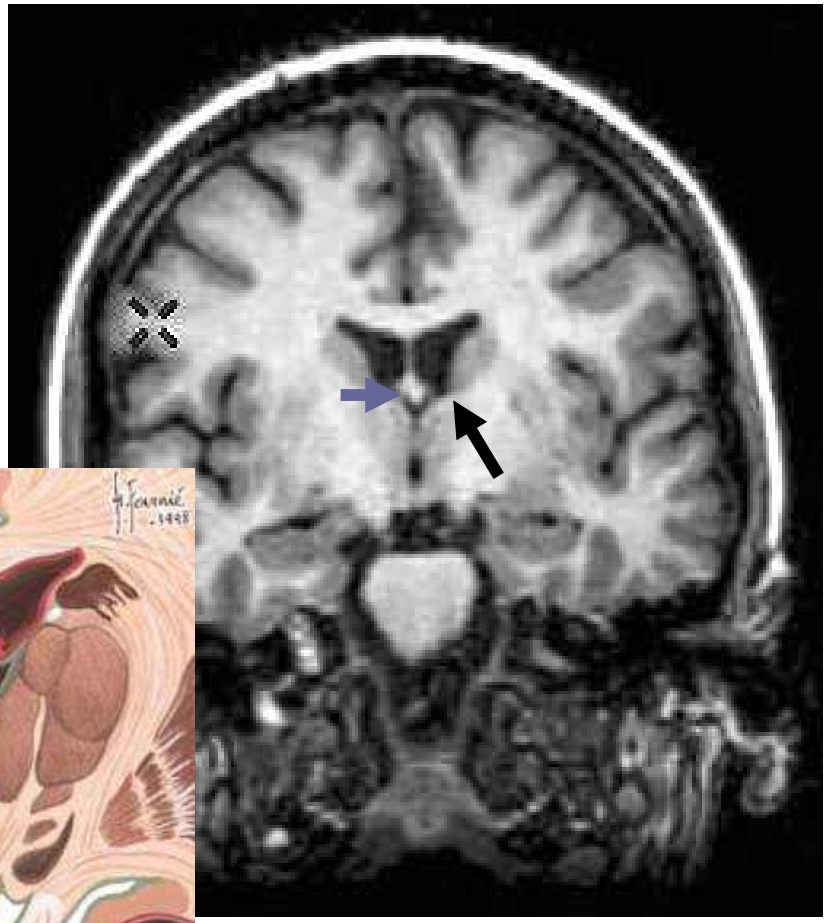


Ventricules

- Fornix
- Plexus Choroïdes
- Sillon thalamostrié

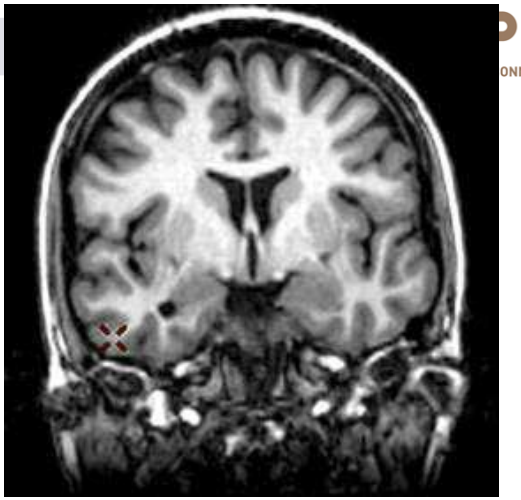


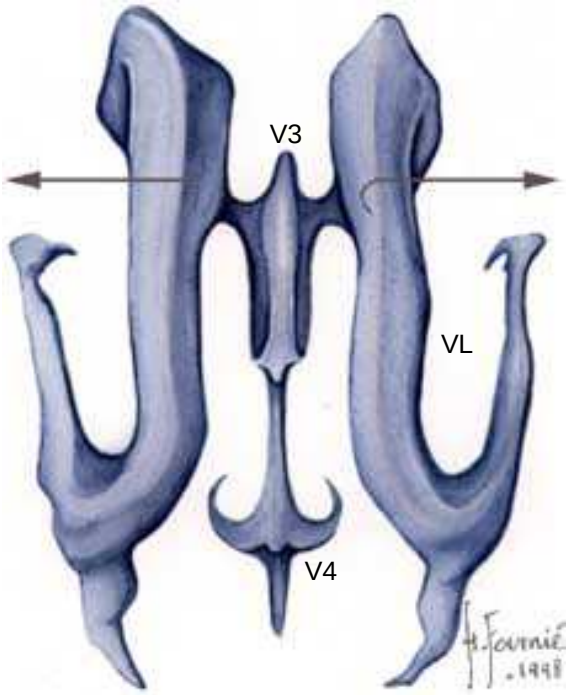
Coupes coronales



Ventricules

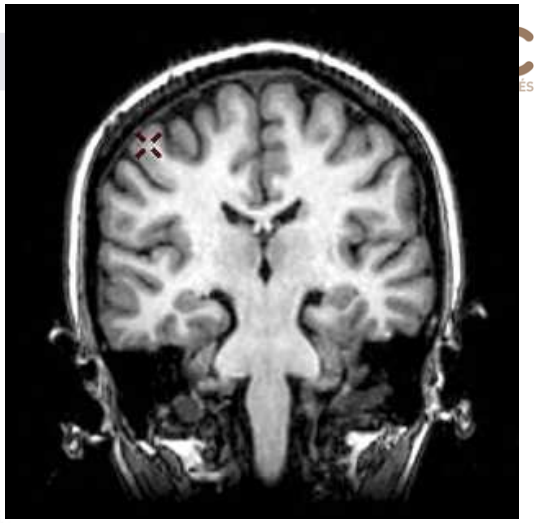
- Cavités épendymaires
- Dilatation -> Ventricules
  - Production
  - Circulation du LCR
- Parois :
  - Noyaux (substance grise)
  - Faisceaux (substance blanche)
  - Régions fonctionnelles importantes
- VL, V3, V4



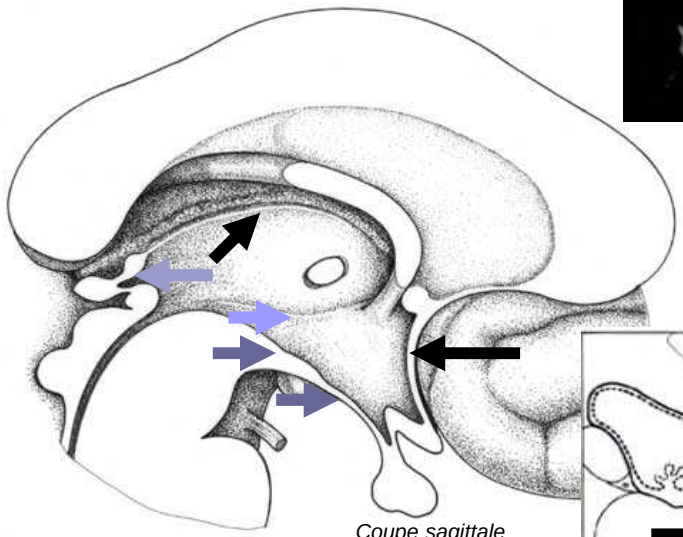


Vue supérieure, écartement des ventricules latéraux

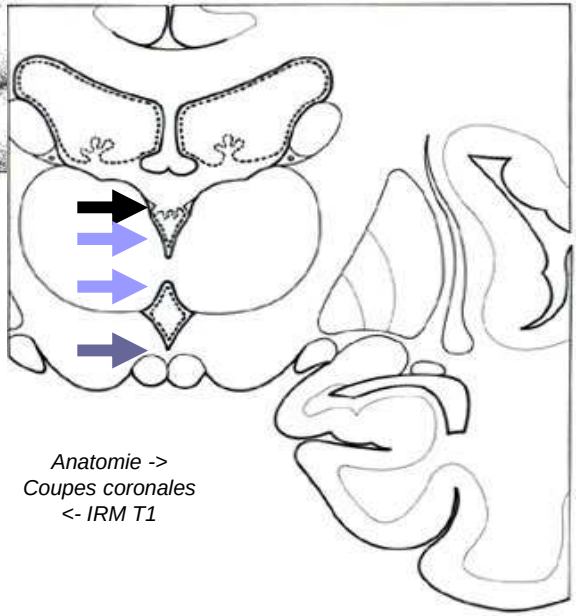
V3



- Plancher
- Toit
- 2 parois latérales
- Paroi antérieure (bord antérieur)
- Paroi postérieure (bord postérieur)



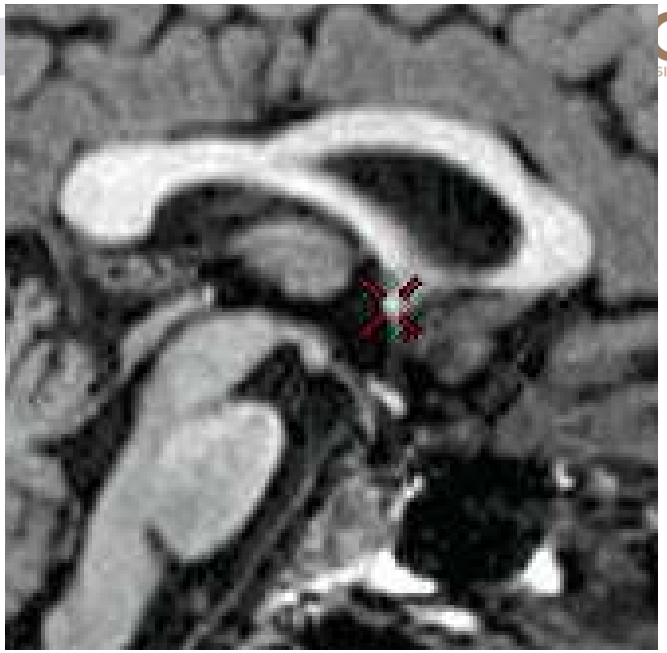
Coupe sagittale

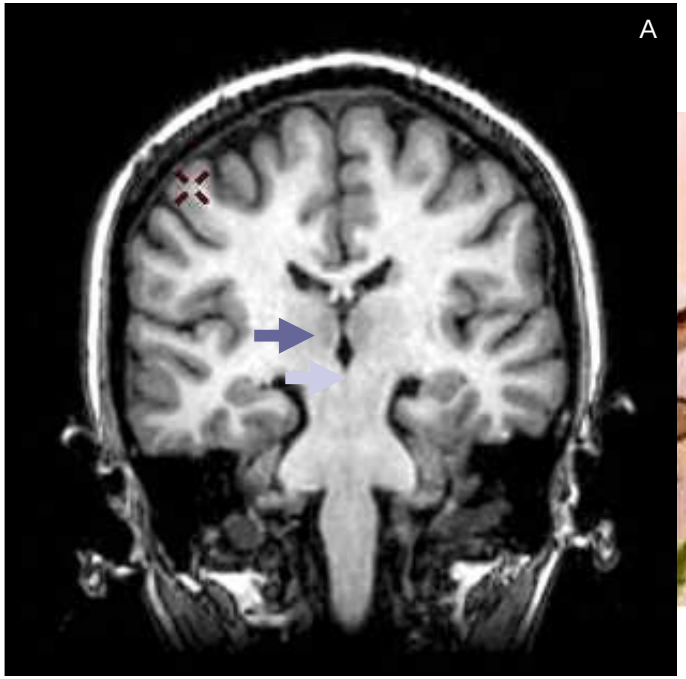


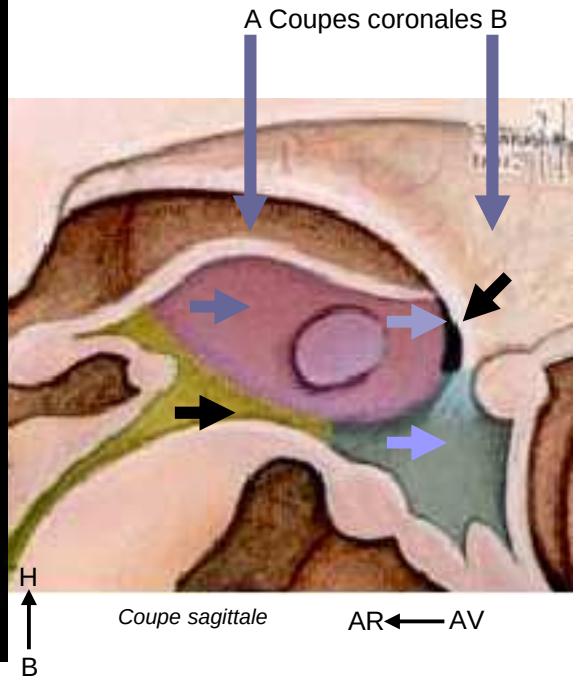
Anatomie ->
Coupes coronales
<- IRM T1

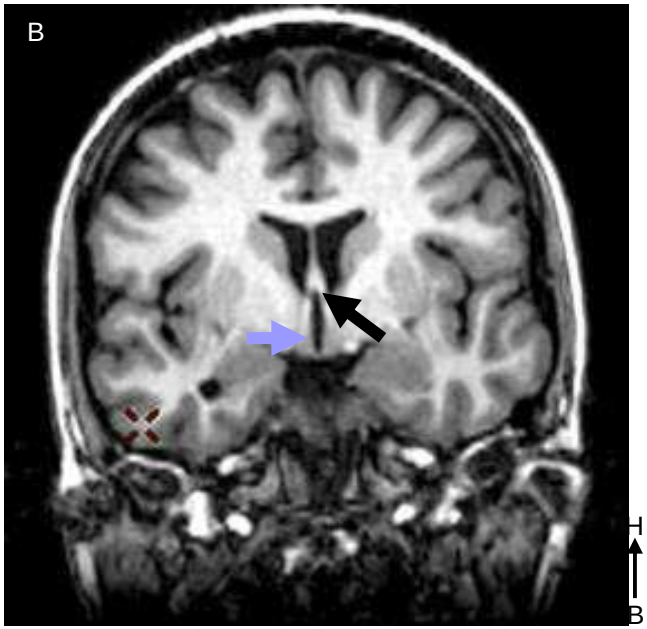
V3 : Paroi latérale

- Thalamus
- Hypothalamus
- Sous-thalamus
- Colonne du fornix
- foramen interventriculaire (trou de Monro)



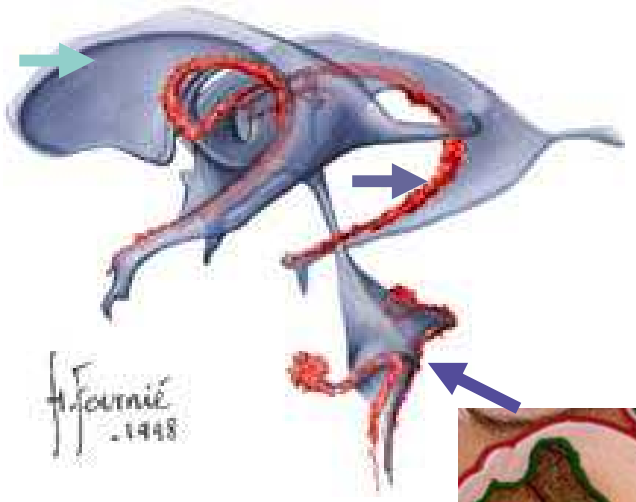


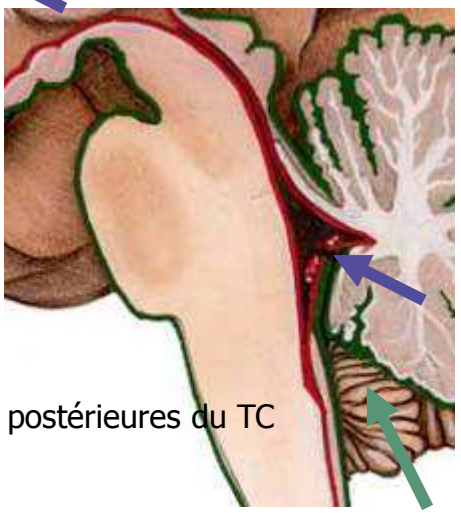




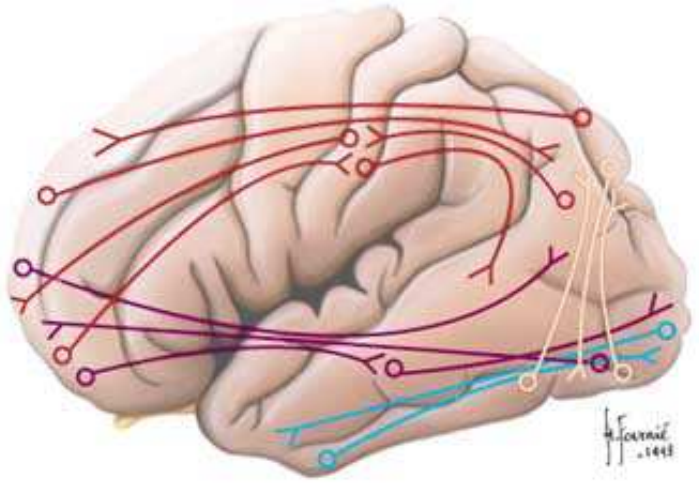
Dynamique du LCR

- Production : VL-V3-V4
  - cavités épendymaires
  - plexus choroïdes
- Communication : ouverture médiane
- Résorption
  - espaces sous-arachnoïdiens
  - granulations arachnoïdiennes
  - Sinus veineux





vues postérieures du TC



SUBSTANCE BLANCHE

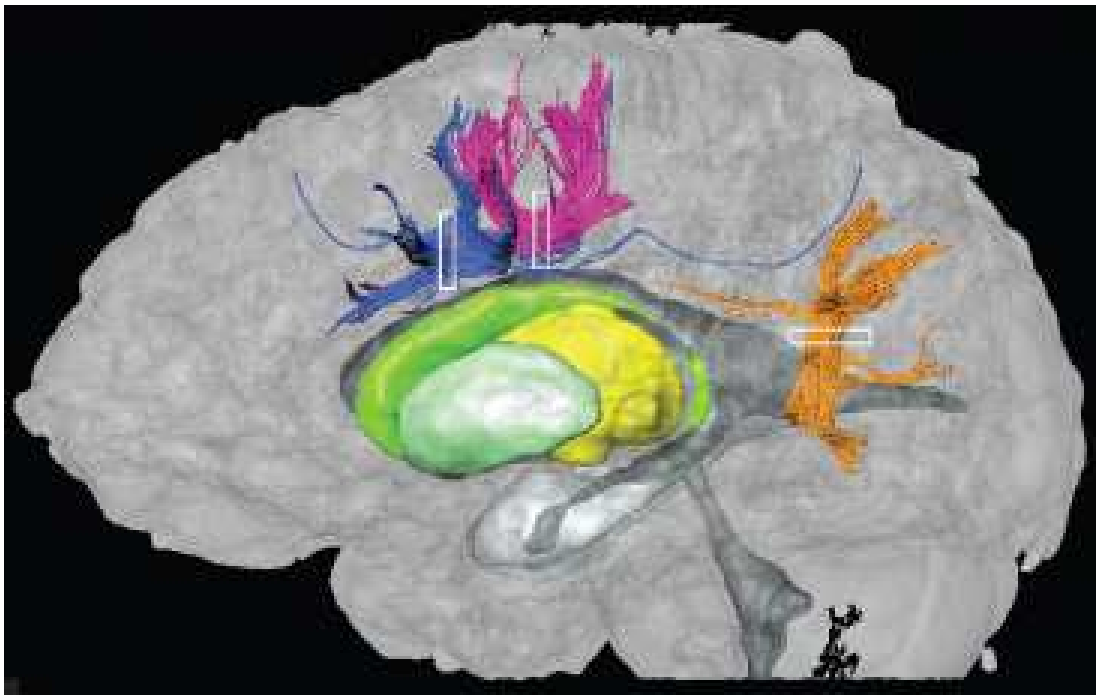
Commissures

- Commissure intrahémisphérique
  - U
- Commissure interhémisphérique
  - CA, CP
  - Corps calleux
- Com. Mixte
  - Fornix

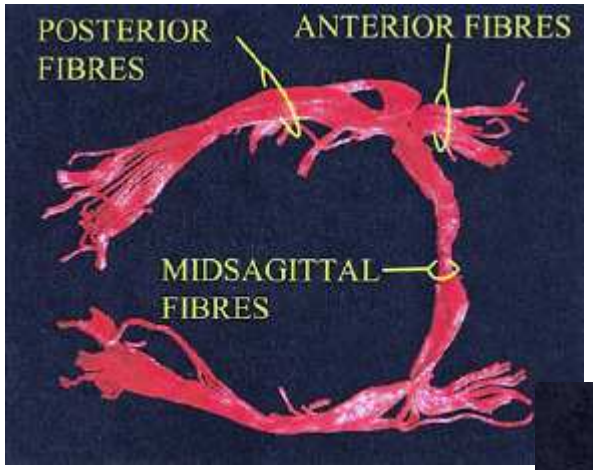
SB : Fibres en U

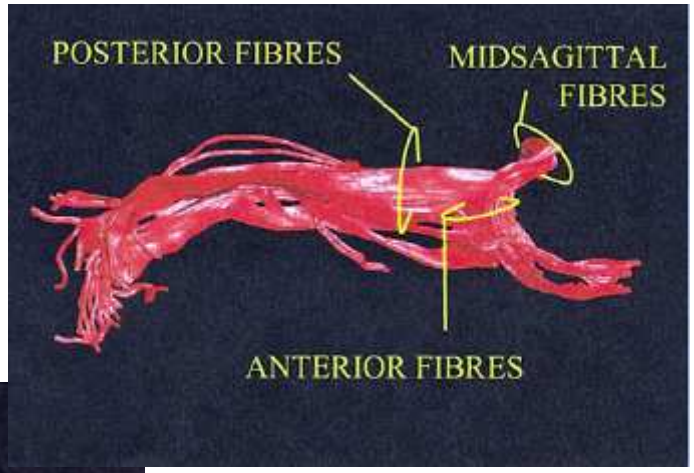
- Fibres arquées (en U)
- Gyri +/- adjacents

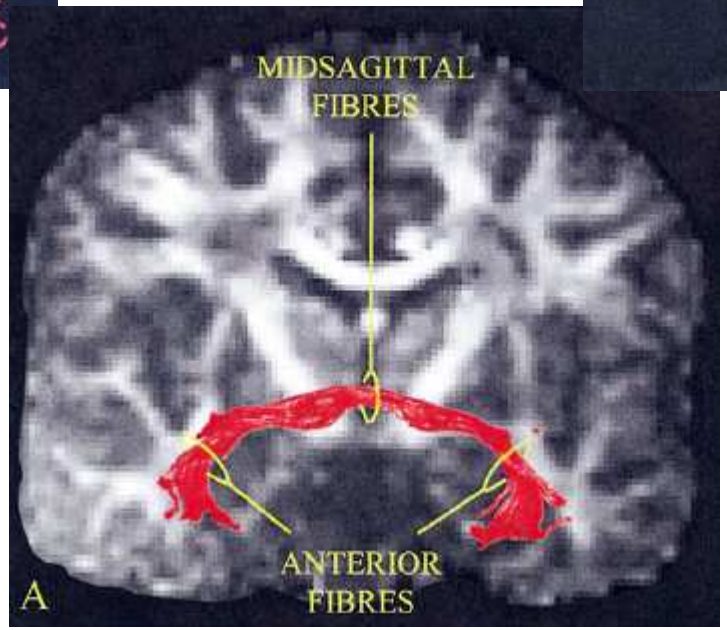
Setsu Wakana, Radiology 2004; 230:77–87



Commissure antérieure



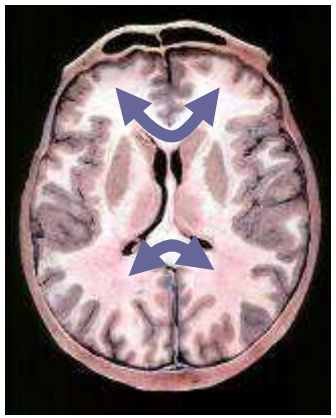


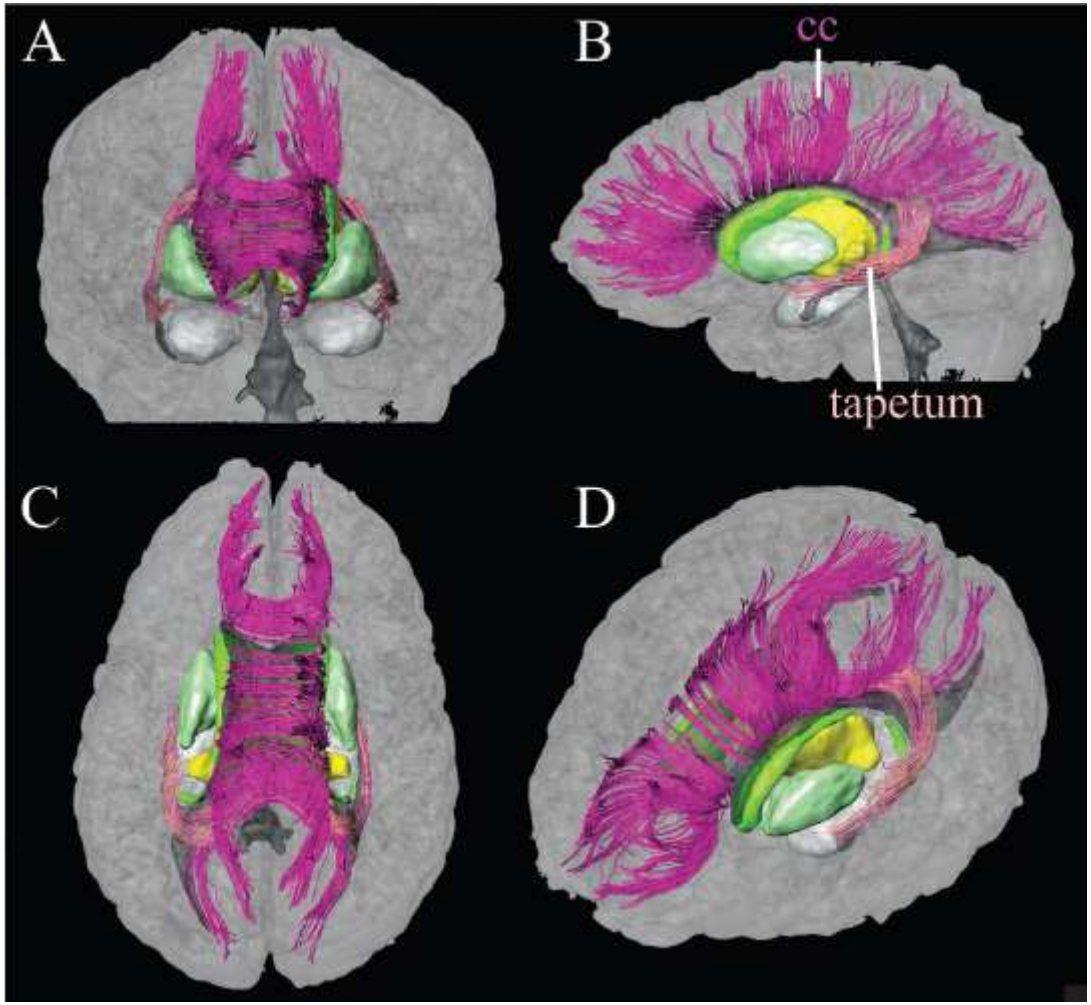


Catani, NeuroImage **17,** 77–94 (2002)

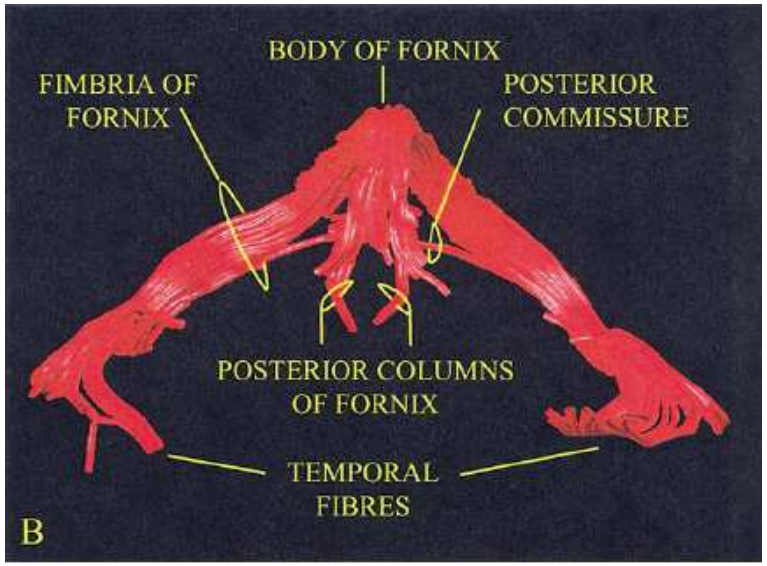
SB : Corps calleux

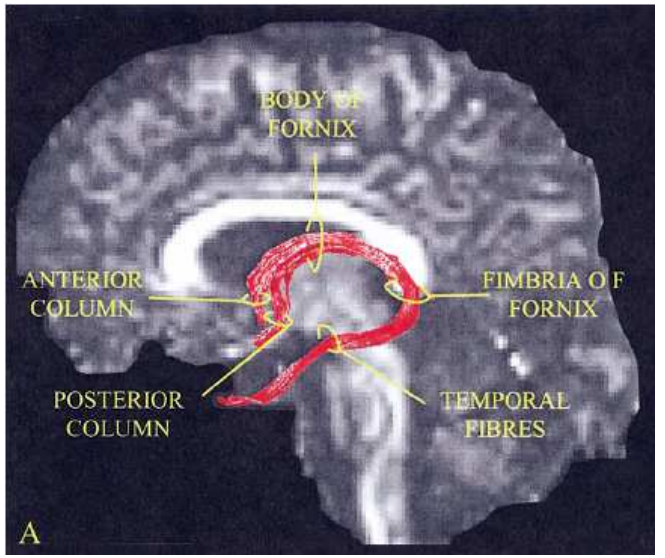
- Interhémisphérique
- Rostrum (bec)
- Genou : F
- Tronc : F, P
- Splenium : T, O
- Tapetum :
  le long du VL
  (entre paroi lat corne post
  et radiation optique)

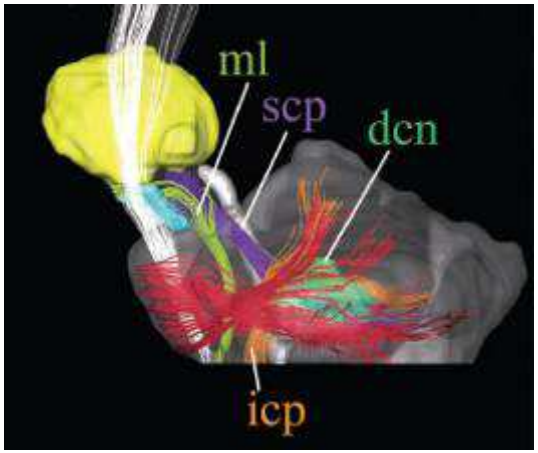




SB : fornix


BODY OF FORNIX
FIMBRIA OF FORNIX
POSTERIOR COMMISSURE
POSTERIOR COLUMNS OF FORNIX
TEMPORAL FIBRES
B


BODY OF FORNIX
ANTERIOR COLUMN
FIMBRIA OF FORNIX
POSTERIOR COLUMN
TEMPORAL FIBRES
A


ml
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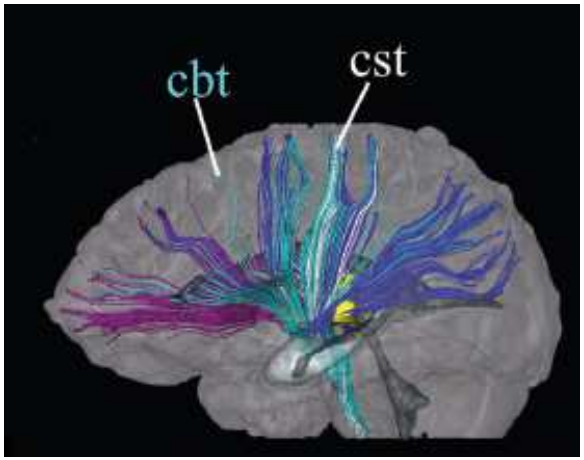
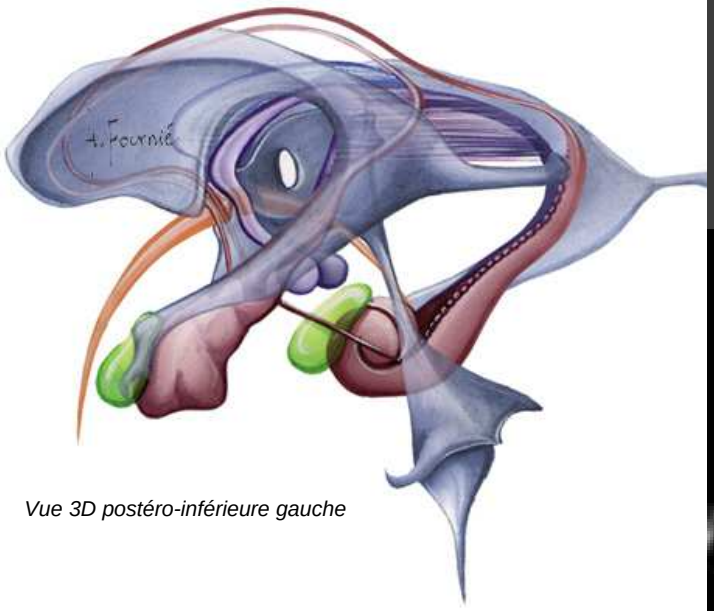
icp


cbt
cst

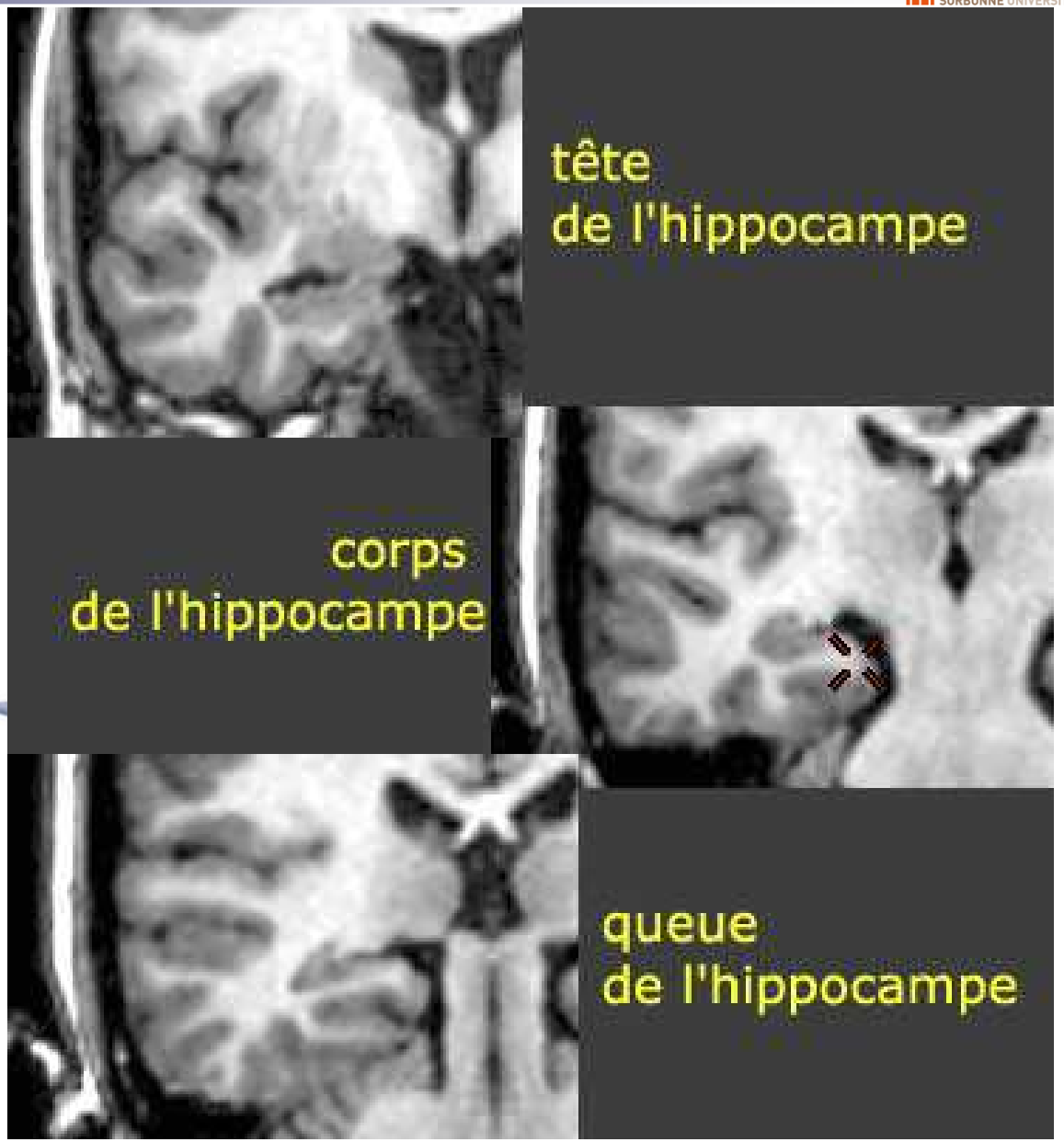
Techniques

Imagerie

- Hippocampe
- GPH



Vue 3D postéro-inférieure gauche

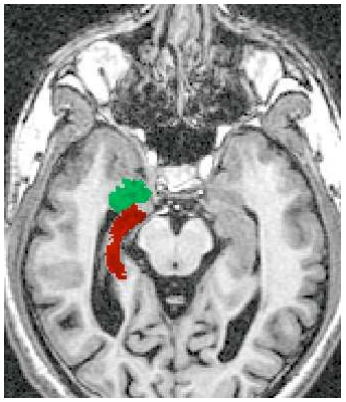
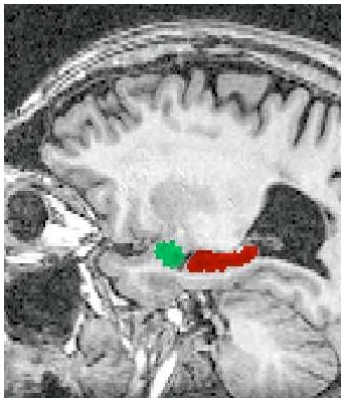
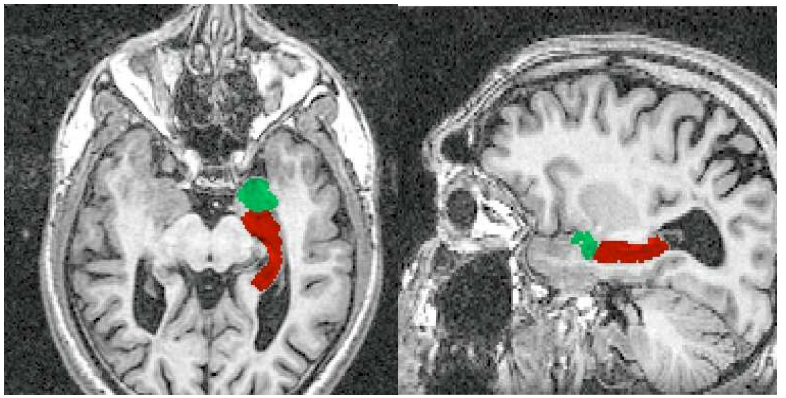
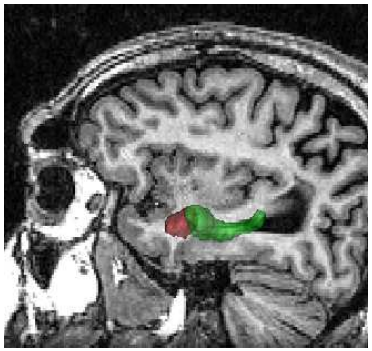
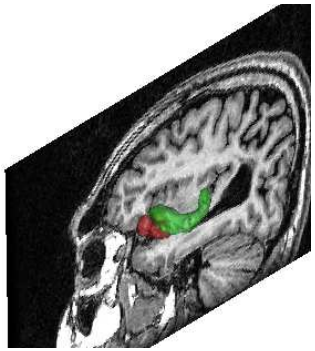
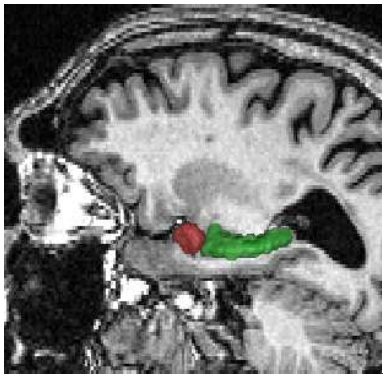
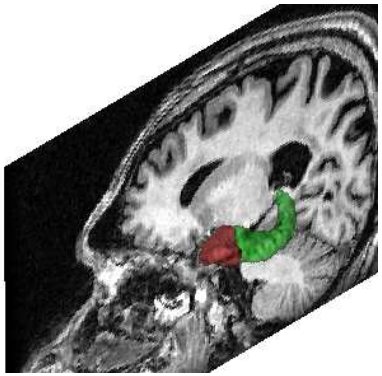


IRM T1 : coupes coronales

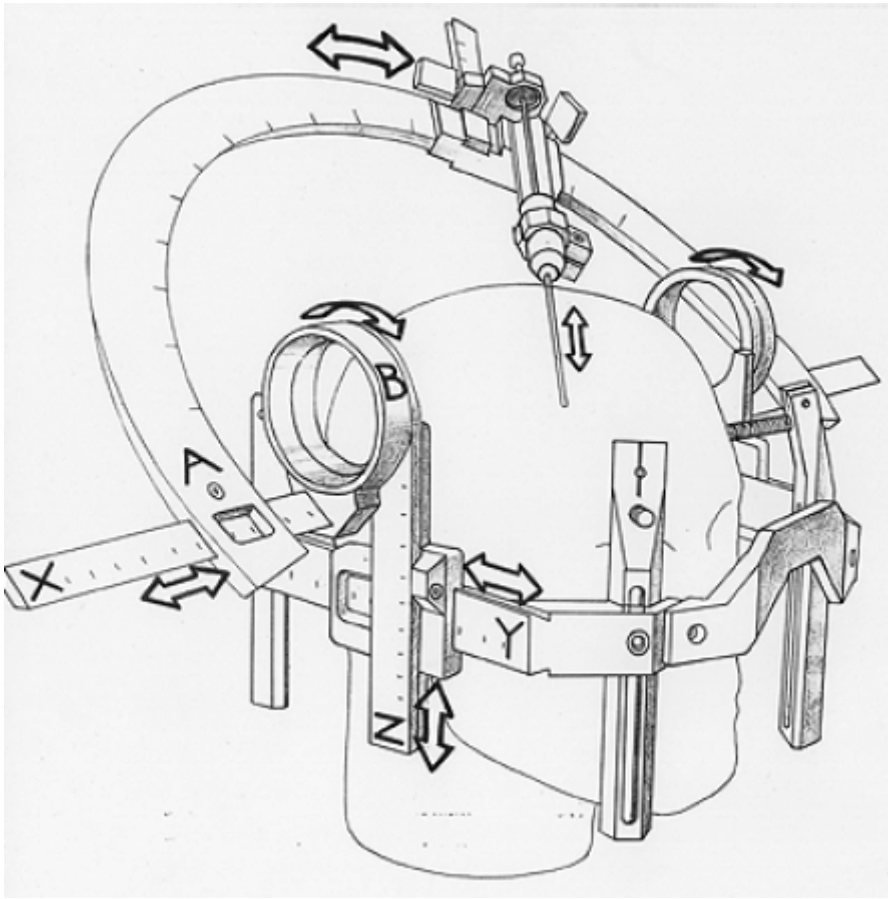
Biométrie

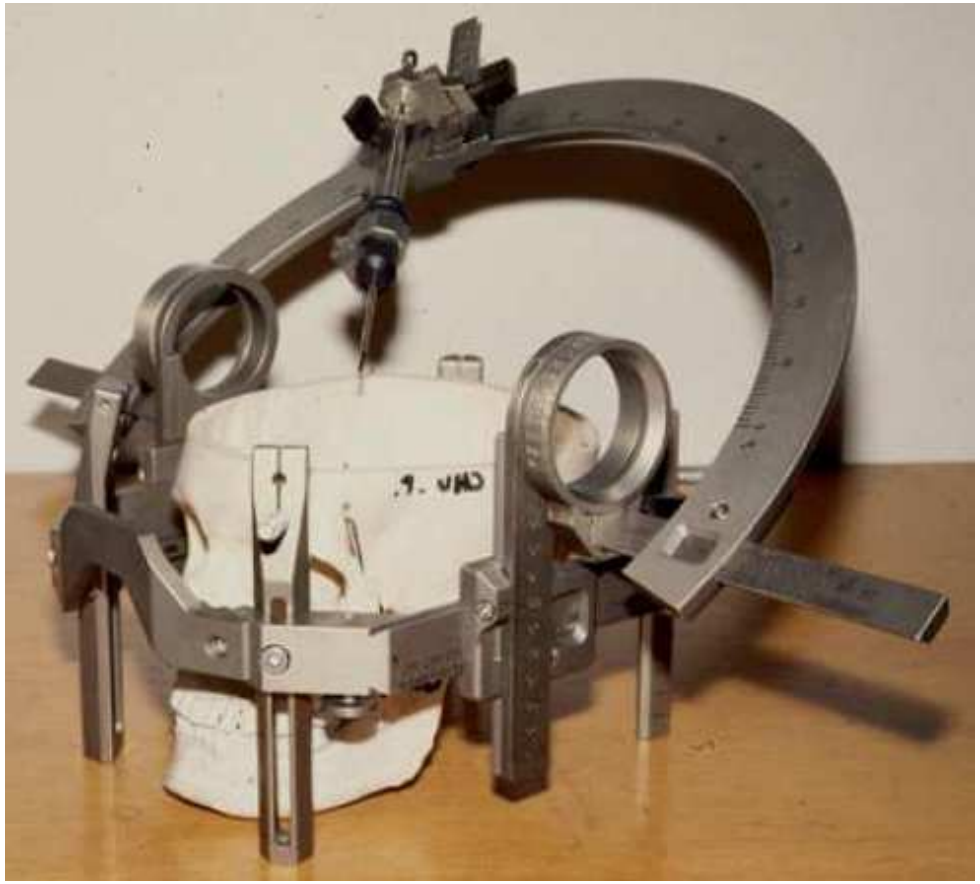
Hippocampe droit 2.033 cm3
Amygdale droite 1.473 cm3

Hippocampe gauche 3.192 cm3
Amygdale gauche 1.861 cm3

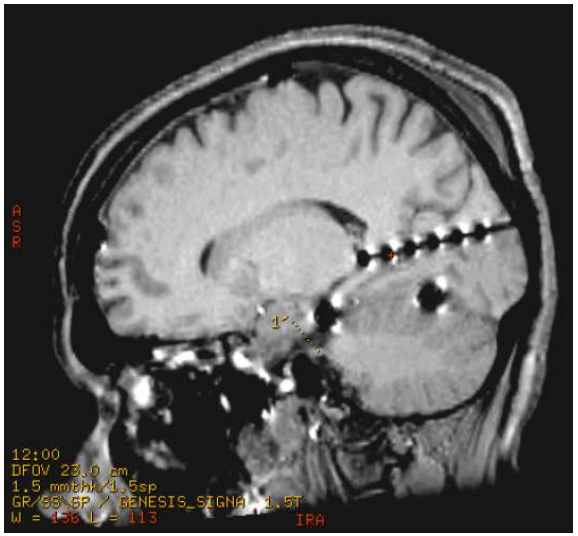








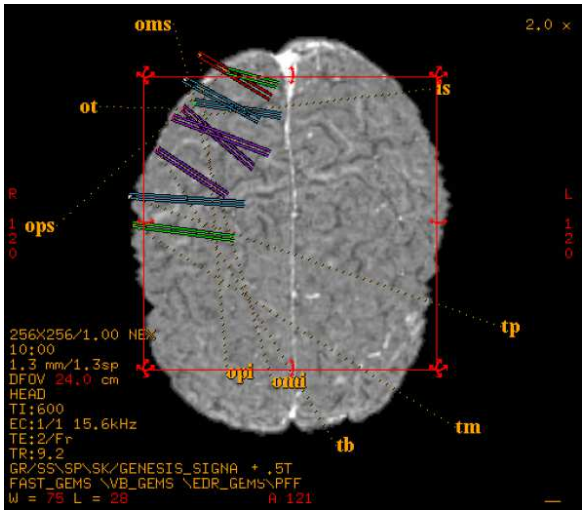
stéréotaxie

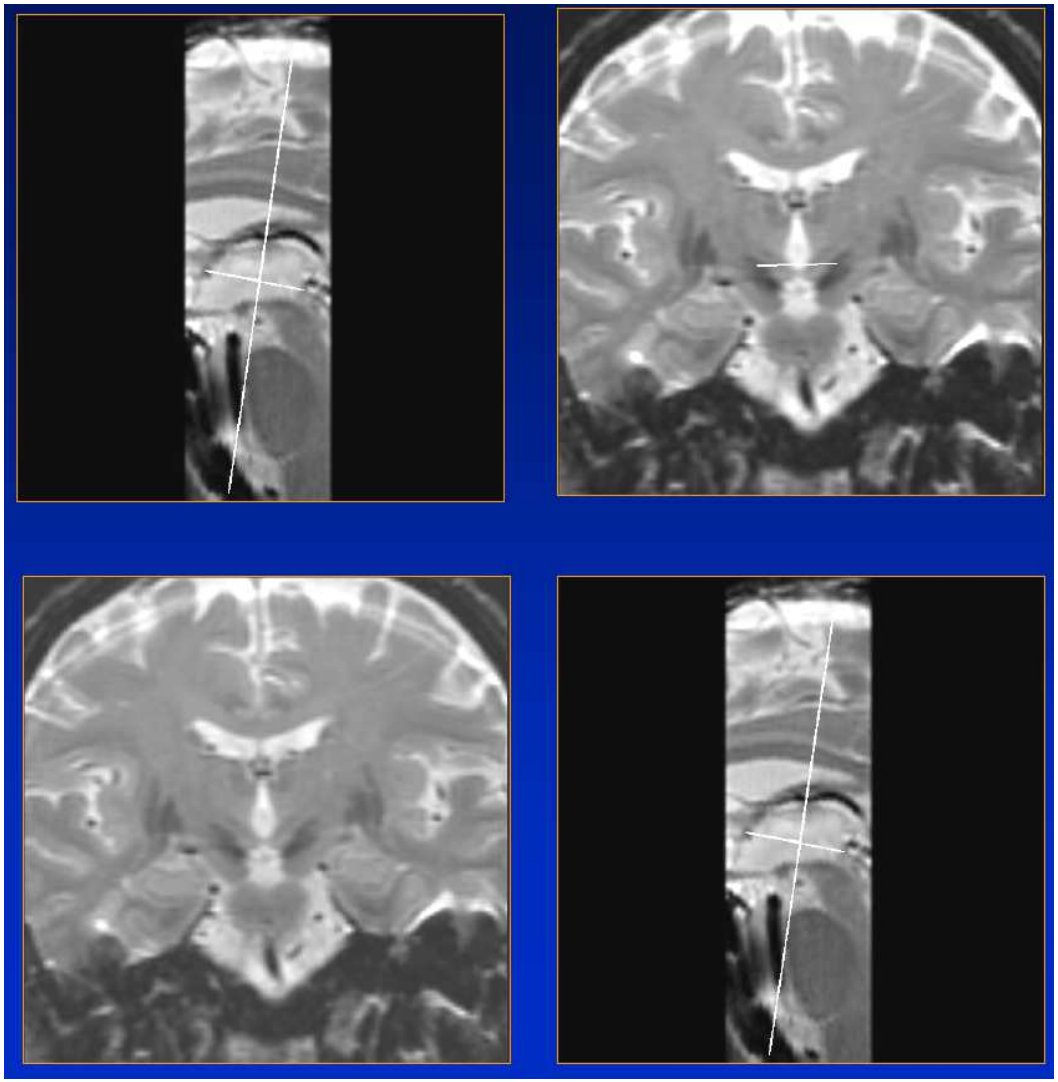




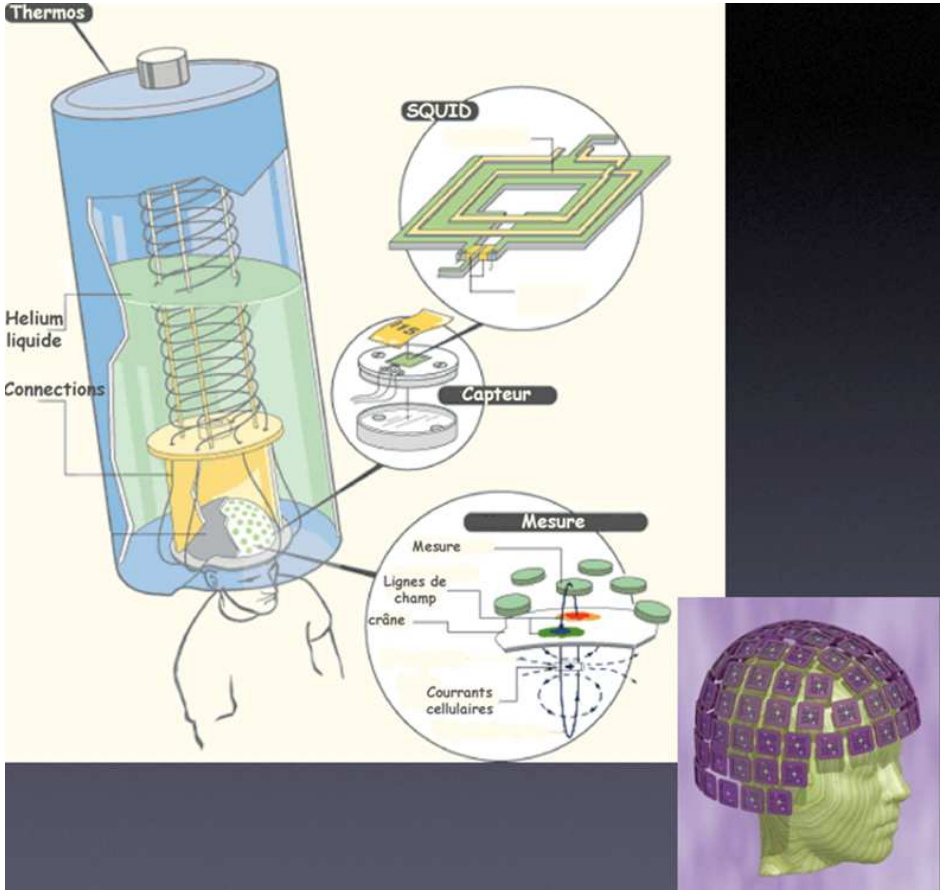
Stéréotaxie





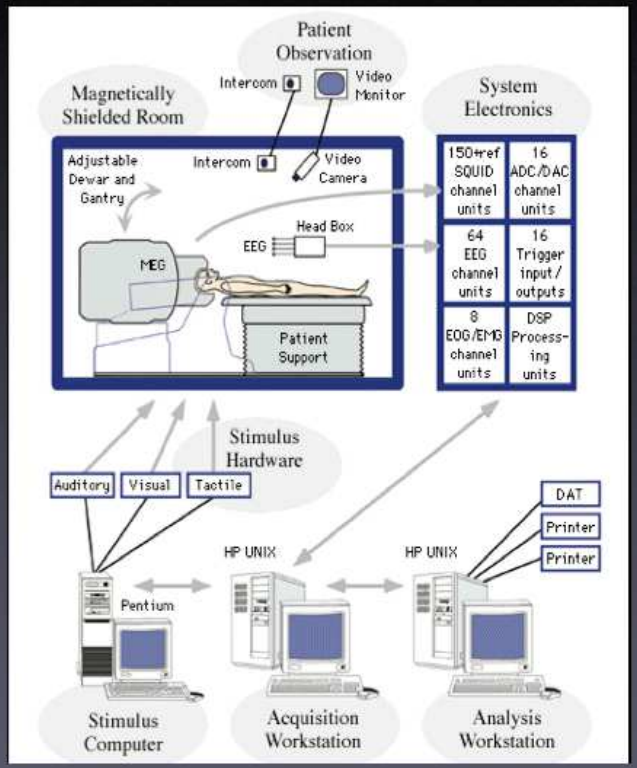


MEG


Thermos
SQUID
Helium liquide
Connections
Capteur
Mesure
Mesure
Lignes de champ
crâne
Courrants cellulaires

MEG

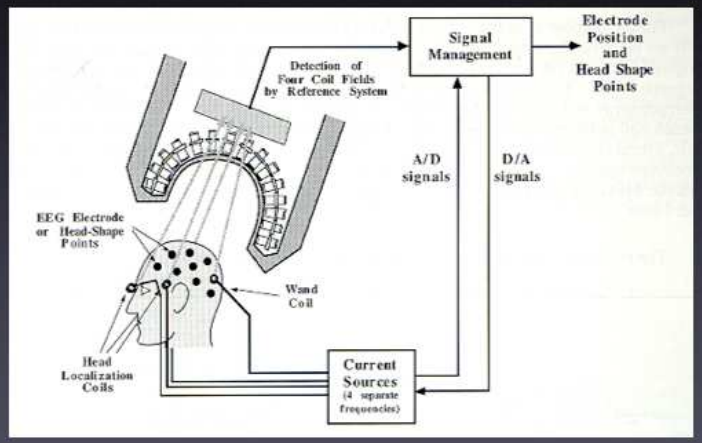
Plateforme d'acquisition



MEG

Recalage avec l'anatomie

Localisation de la tête dans le capteur MEG



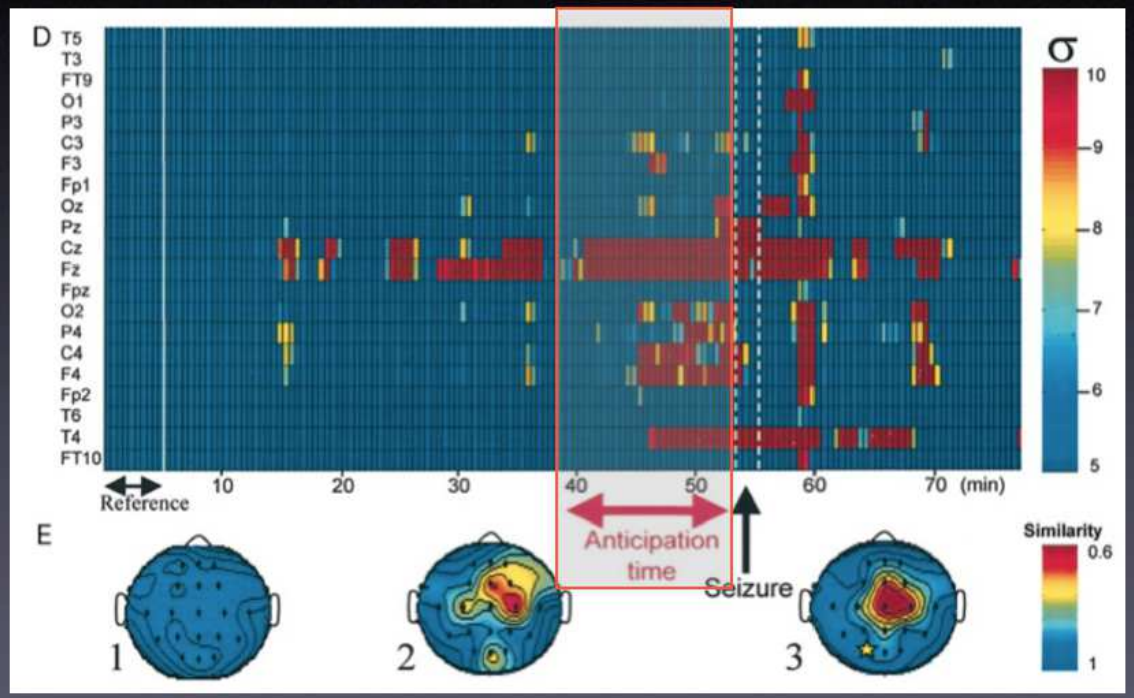
On définie un repère patient avec trois fiducials :

- Nasion
- Left Pre Auricular Point
- Right Pre Auricular Point

On mesure le champ magétique induit par les bobines et on les localise

Anticipation des crises

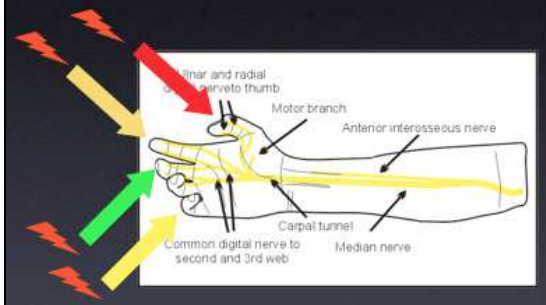
J. Martinerie - C Adam - LENA UPR 640

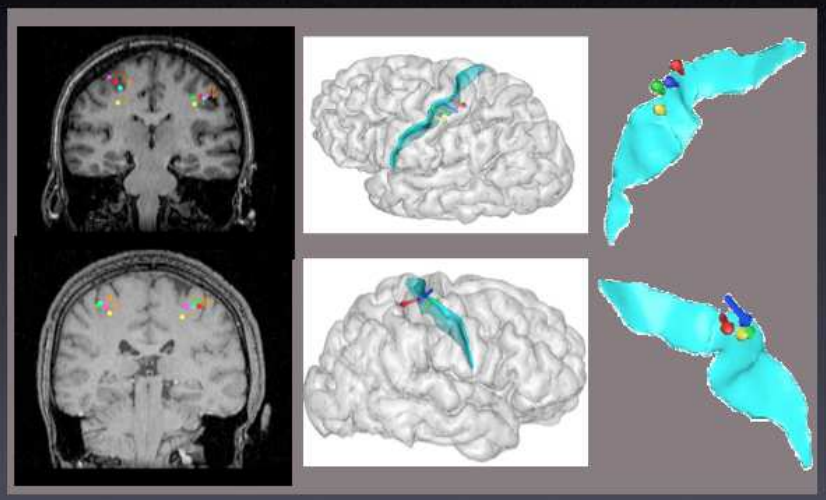


MEG

Dystonie

St-Antoine et INSERM U289, M.Vidailhet - EMI 0344, S. Meunier – LENA CNRS UPR 640, L. Garnero , B. Renault





MEUNIER S., **GARNERO** L., **DUCORPS** A., MAZIERES L., LEHERICY S., TEZENAS DU MONTCEL S., **RENAULT** B., VIDAILHET M.(2001) Human brain mapping in dystonia reveals at once endophenotype and adaptative reorganization, Annals of Neurology, 50 :521-527.

MEUNIER S., LEHERECY S., **GARNERO** L., VIDAILHET M. (2003) Dystonia : Lessons from Brain Mapping , Neuroscientist, 9, 1, 76-81

TEP - Principes

- Imagerie fonctionnelle nucléaire
- Images représentant la distribution temporelle, régionale et quantitative d ’un radiotraceur émetteur de positons

TEP : Etapes

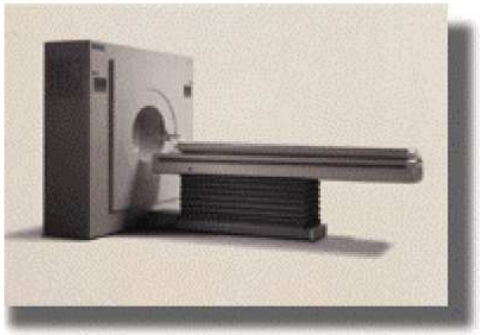
Production du radio-isotope radioactif

Incorporation radio-isotope dans molécule

CHIMIE

TRACEUR

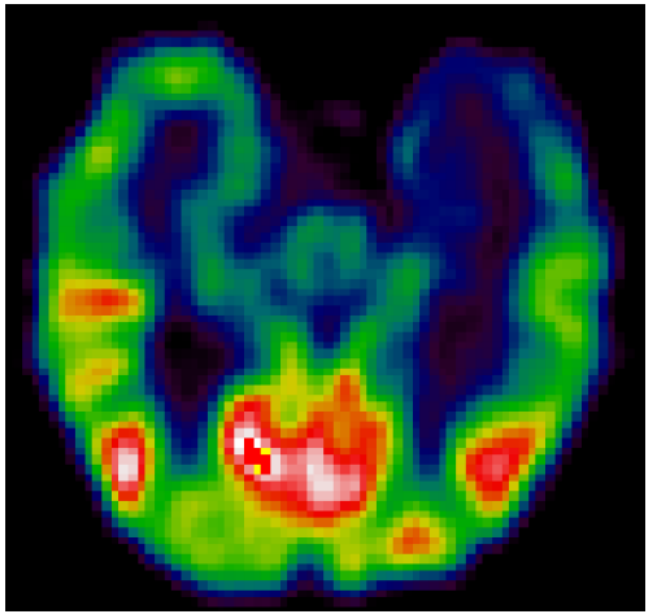
Injection dans l 'organisme



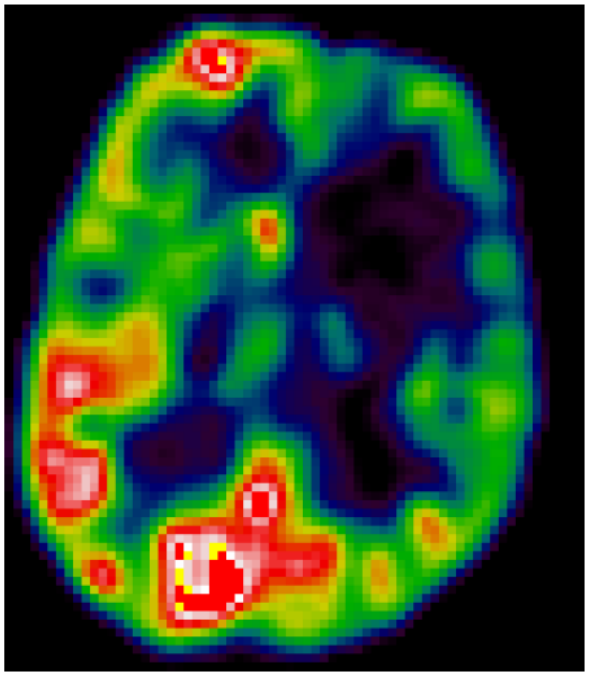
Détection externe des photons gamma

Reconstruction des images

Exemple



Epilepsie
Temporale



Epilepsie
Frontale

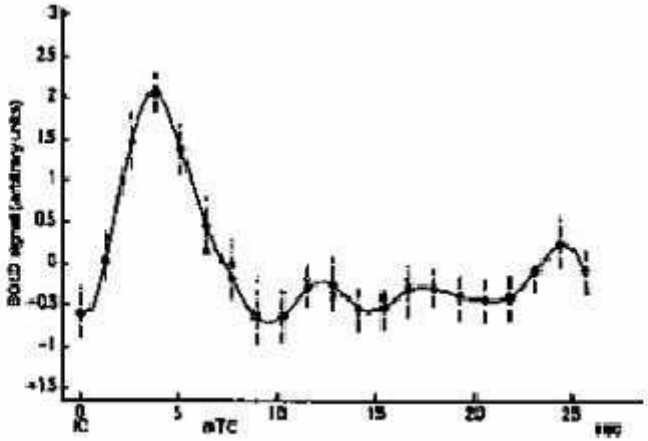
IRMf : Principes

- L'effet BOLD dépend de:
  - débit sanguin cérébral
  - volume sanguin cérébral
  - taux métabolique cérébral de consommation d'oxygène.
- De façon générale, l'activation cérébrale entraîne le plus souvent une baisse de la concentration relative de déoxyhémoglobine et donc une augmentation de signal IRM.

IRMf

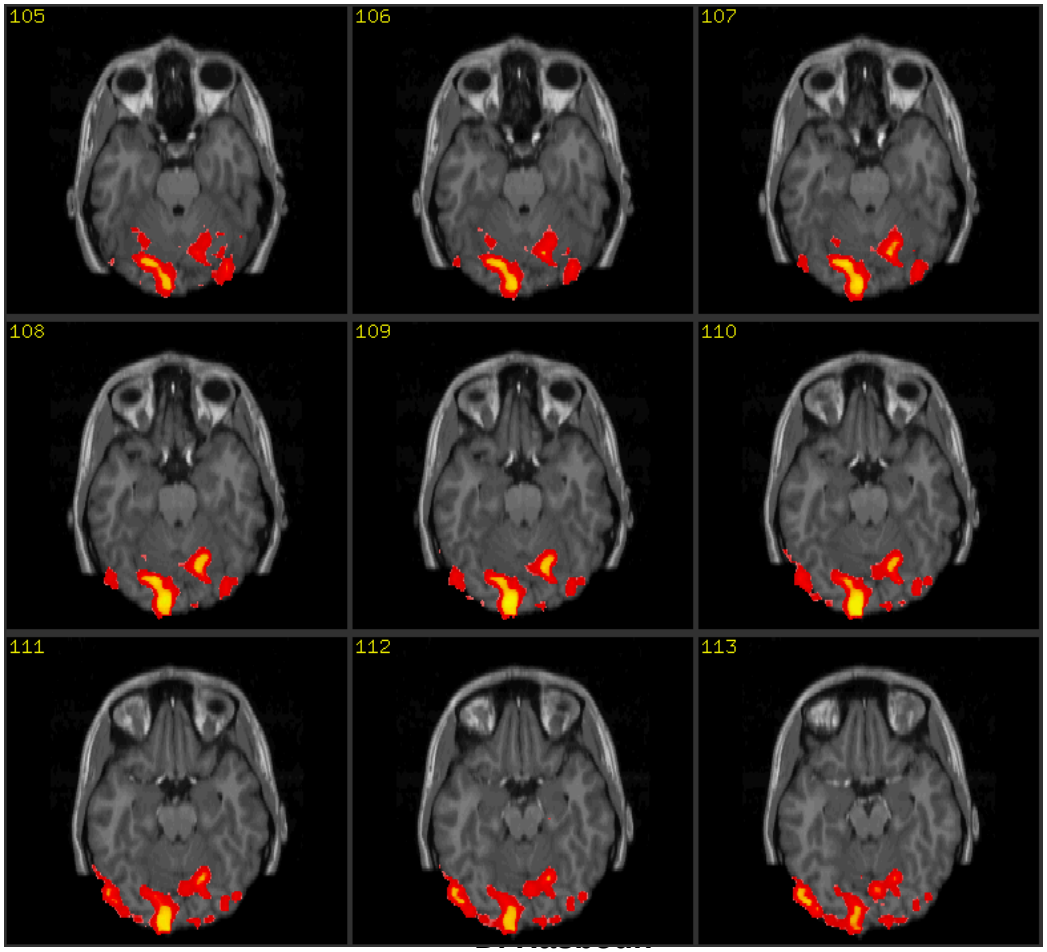
La réponse hémodynamique

- L'activation neuronale est un phénomène électrique rapide.
- La réponse hémodynamique obtenue par effet BOLD met en jeu des processus physiologiques encore méconnus qui interviennent au niveau des capillaires sanguins → phénomène lent (15 s).

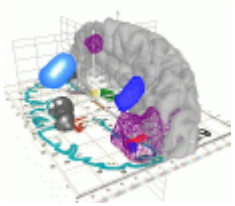


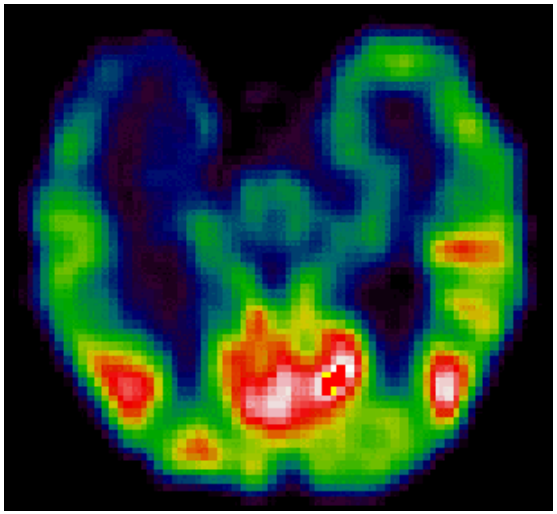
obtenue après moyennage de plusieurs évènements

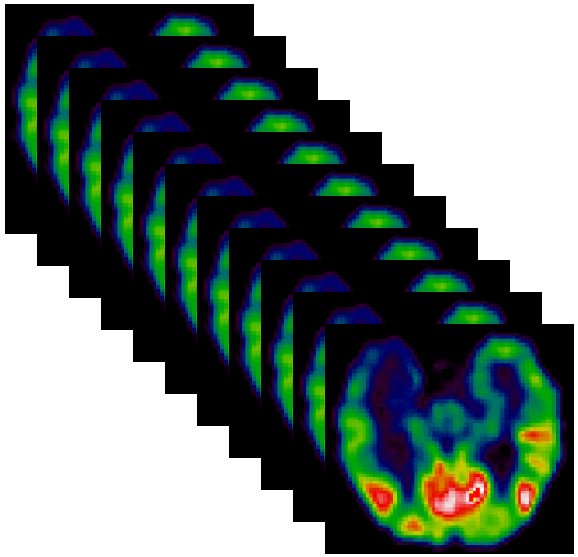
IRMf

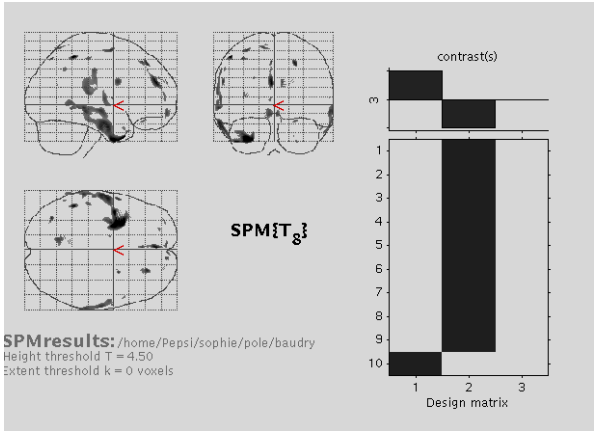


Techniques d'analyse







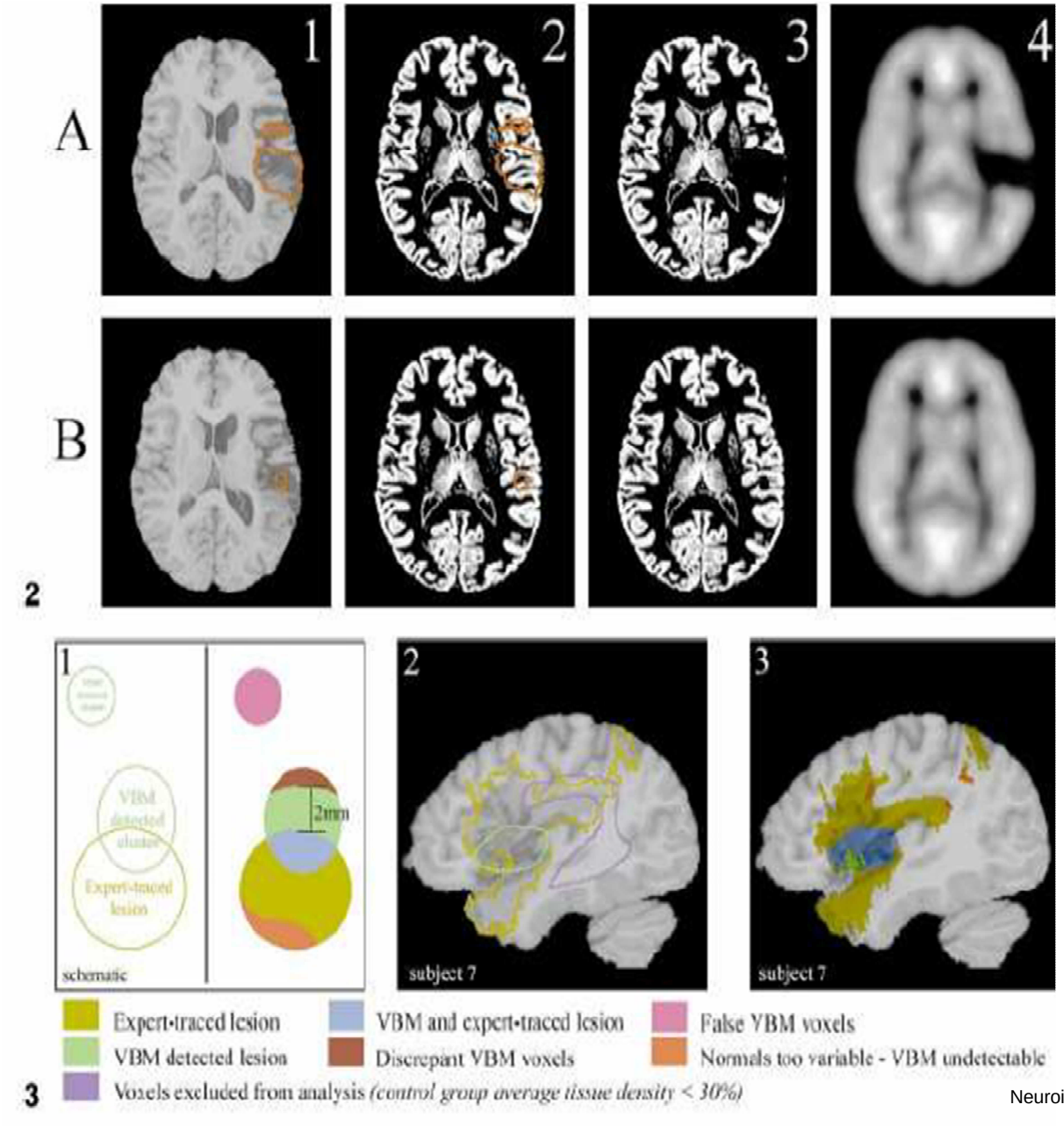


Réalignements

normalisation

statistiques

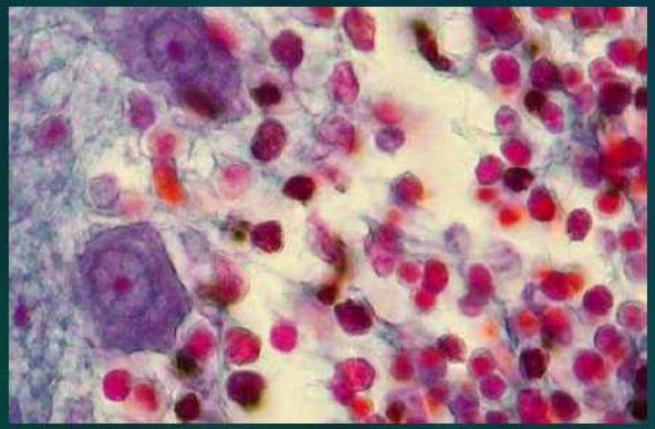
VBM



Neuroimage 20 (2003) 1438-1454

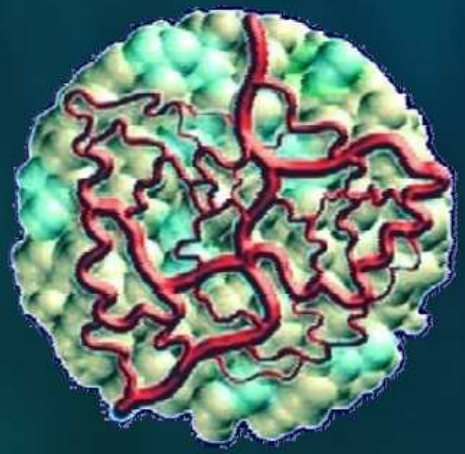
Diffusion Perfusion

Diffusion isotropique



Architecture tissulaire

Perfusion

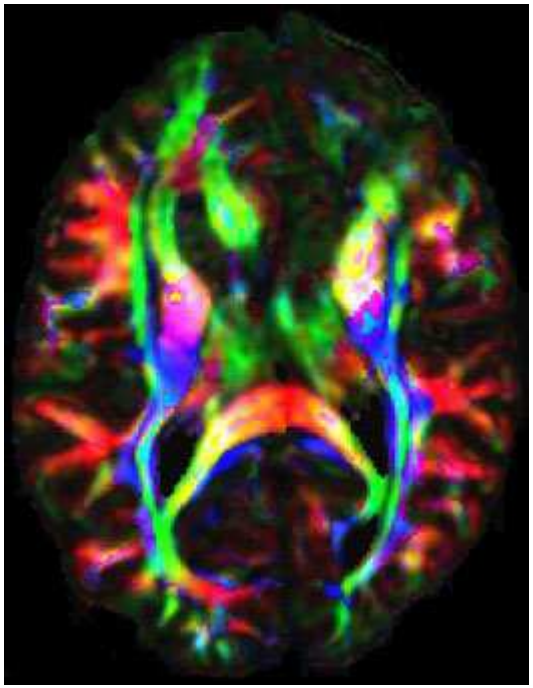


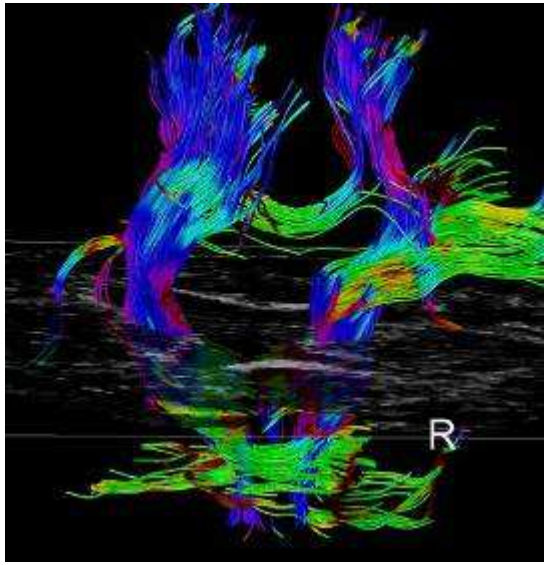
Micro-Vascularisation (irrigation tissulaire)

Tenseur de diffusion

Direction des axones

Tractographie





D. Hasboun

SMT

- Unique / Répétitive
- <1Hz : inhibition
- >3Hz excitation
- Pot Ev Mot (PEM) explore les voies de la motricité
- Thérapeutique
  dépression…
- recherche