CISC 3250
Systems Neuroscience

Neural systems and neuroanatomy

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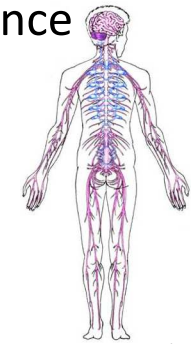
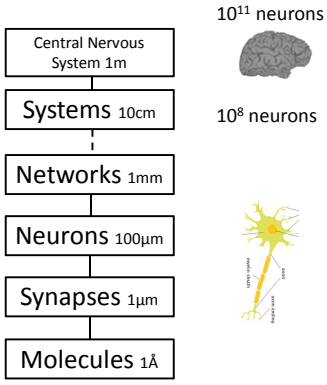
JMH 328A



1

Levels of organization

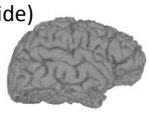


2

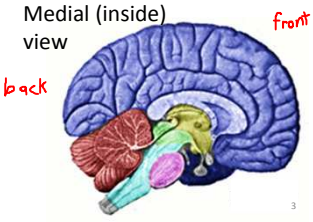
Elements of the central nervous system

- Cerebral cortex
- Thalamus
- Hypothalamus
- Brainstem
- Cerebellum
- Spinal cord

Lateral (side) view



Medial (inside) view

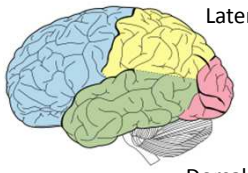


3

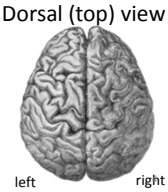
Cerebral cortex broad divisions

- Four lobes
  - Frontal
  - Parietal
  - Temporal
  - Occipital
- Two hemispheres: left and right, linked by corpus callosum

Lateral view

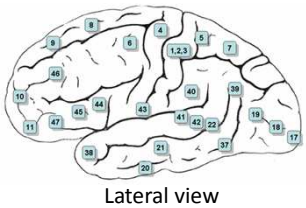


Dorsal (top) view

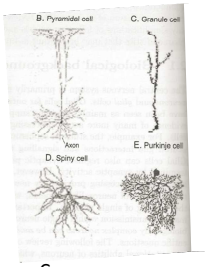


Brodmann areas

- Divide brain based on arrangement of neurons in each region



Lateral view

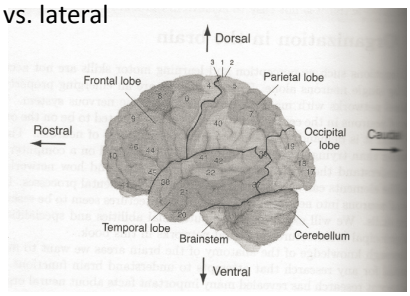


Common neuron types

5

Navigating the cerebral cortex

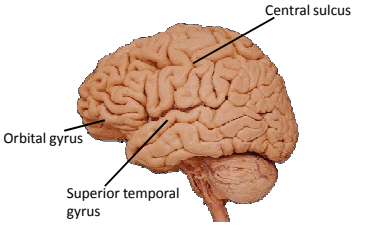
- Dorsal (top) vs. ventral (bottom)
- Anterior/rostral (front) vs. posterior/caudal (back)
- Medial vs. lateral



6

Dividing the cerebral cortex surface

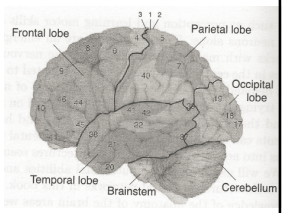
- Sulci – folds
- Gyri – bulges



7

Functional divisions

- Frontal
  - Future planning, personality, judgment, social behavior
  - Motor cortex
- Temporal
  - Auditory cortex
  - High-level vision
- Parietal
  - Spatial vision
  - Primary sensory cortex
  - Visual-auditory-spatial sensory integration
- Occipital
  - Primary visual cortex

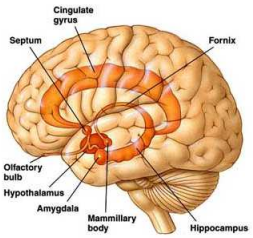


8

Limbic system

Medial area of cerebral cortex

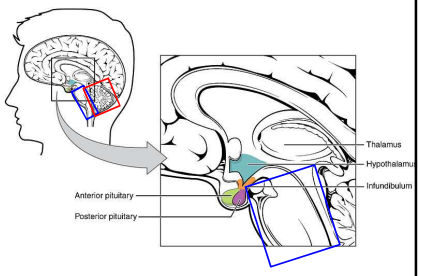
- Hippocampus: memory
- Amygdala: emotion
- Cingulate and parahippocampal gyri



9

The brain beyond the neocortex

- Thalamus
- Hypothalamus
- Brain Stem
- Cerebellum



10

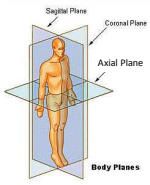
The brain beyond the neocortex

- Thalamus
  - All sensory information (except olfaction/smell) passes through
- Hypothalamus
  - Emotions, memory
  - Homeostasis: temperature, sleep/alertness, hunger
- Brain Stem
  - Conduit for spinal cord and cranial nerves
  - Respiratory and cardiac activity
- Cerebellum
  - Plan, coordinate, modify motor activities

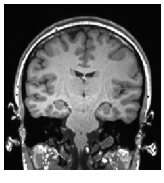
11

Two dimensional slices of the brain

- Axial (parallel with ground)
- Coronal (halo)
- Sagittal (in profile)

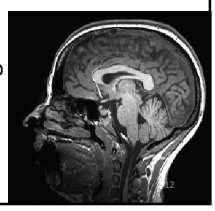


Axial



Coronal

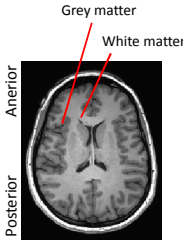
Sagittal



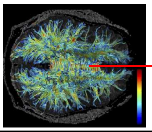
12

Grey and white matter

- Grey matter – soma, performs "computations"
- White matter (60% of brain) – axons, transmits information
- Tractography finds links between brain regions



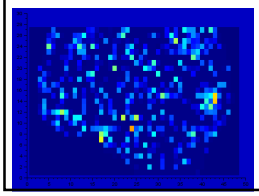
Axial



13

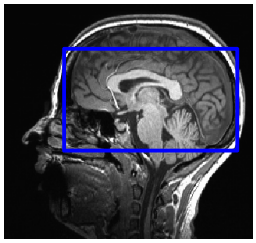
fMRI activity

```
-->loadmatfile('S1_data.mat')

-->size(BrainMtx)
 ans  =

   48.   48.   27.

-->exec('disp2d.sci')

-->figure;disp2d(BrainMtx(24,:,:),%F);
```



Measuring concentration of oxygenated blood

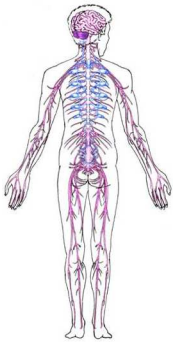
High firing -> high blood concentration



14

At the periphery

- Spinal cord
  - Muscles: motor
  - Mechanoreceptors: touch
- Sensory organs
  - Ears: Hearing and balance
  - Eyes: Vision
  - Olfactory bulb: smell



15

Cortical division review

- Frontal
  - Future planning, personality, judgment, social behavior
  - Motor cortex
- Temporal
  - Auditory cortex
  - High-level vision
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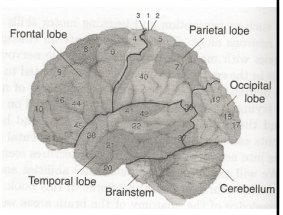
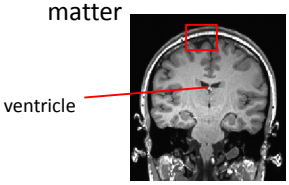


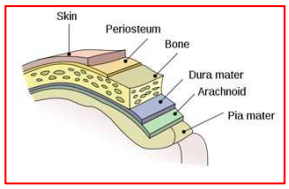
16

Non-functional anatomy

- Vessels of the brain
- Ventricles with cerebrospinal fluid
- Casing around the brain – pia matter, dura matter



Coronal

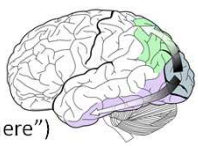


17

Cortical processing networks

Perception "hierarchy"

- *Primary sensory areas* capture basic sensory properties, or "features"
- More complex representations in higher sensory areas
- Example: Vision
  - Primary visual cortex in occipital pole
  - Anterior flow of information in ventral ("what") and dorsal ("where") pathways

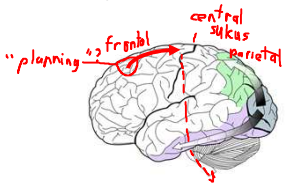


18

Cortical processing networks

Action

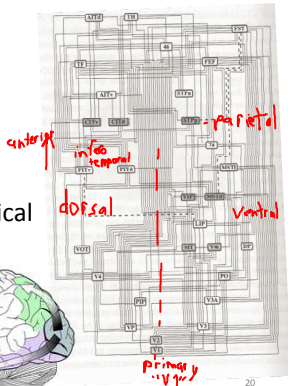
- Motor planning and performance is achieved in stages within the frontal lobe
- Motor correction is supervised by the cerebellum

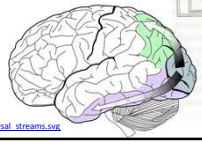


19

Complexity of cortical networks

- *Feedback*: connections in both directions along cortical "pathways"
- *Lateral connections*: collaboration among cortical regions at similar stage of processing





20

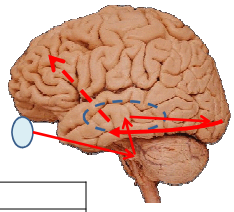
Rapid data transmission in the brain

Psychology/computational theory

- Recognizing object category in 400ms (Thorpe)

Biology/implementation

- Multi-stage processing
- Rapid spike transmission



Spike velocity on myelinated axon	120 m/s
Synaptic transmission velocity	0.6 ms
Spike duration	1 ms
Axon length	5 – 1000 mm

21

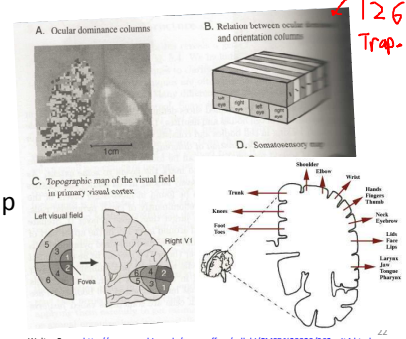
Cortical modules

Groups/"columns" of neurons encoding same property

Subdivisions within cortical region

- Retinotopy
- Body part map *Homunculus*
- Tonotopy

page 126 Trap.



Walter Crane, http://www.csuchico.edu/~pmccaffrey/syllabi/CMSD%20320/362unit4.html

22

Cortical modules

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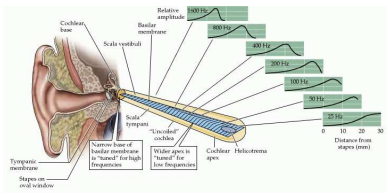


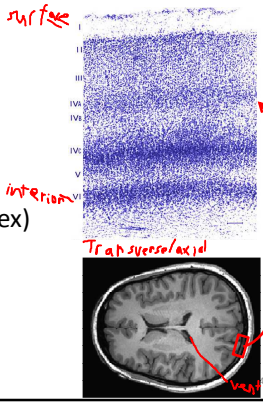
http://www.ncbi.nlm.nih.gov/books/NBK10946/

23

Local cortical structure

Six cortical layers

- Layers contain different neuron types – 6 layers
- Nissl staining shows concentration of somas (here, primary visual cortex)



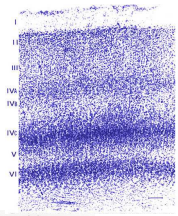
Local cortical structure

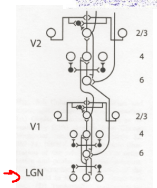
Six cortical layers

- Layer I contain white matter
- Layer IV for input
- Layer V for output
- Layers II & III for lateral connections

Modeling connections

- White: excitatory
- Black: inhibitory





th alamus

25