9.09J/7.29J - Cellular Neurobiology, Spring 2005
Massachusetts Institute of Technology
Department of Brain and Cognitive Sciences, Department of Biology
Instructors: Professors William Quinn and Troy Littleton
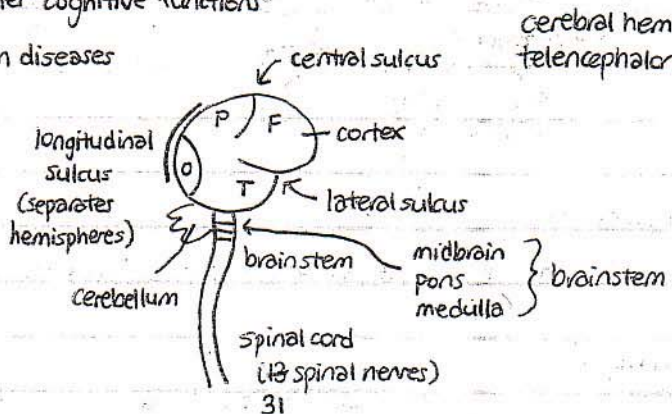Lecture notes courtesy of Wyan-Ching Mimi Lee. Used with permission.

3/29/04

concepts to learn:

- anatomy

- development (pattern formation) (axonal pathfinding) (synapse formation) (fine tuning connections)
  activity-dependent ↓

- how brain works (sensory → behavior)

  - sensory systems (visual, olfactory, auditory, temperature, pain, etc)

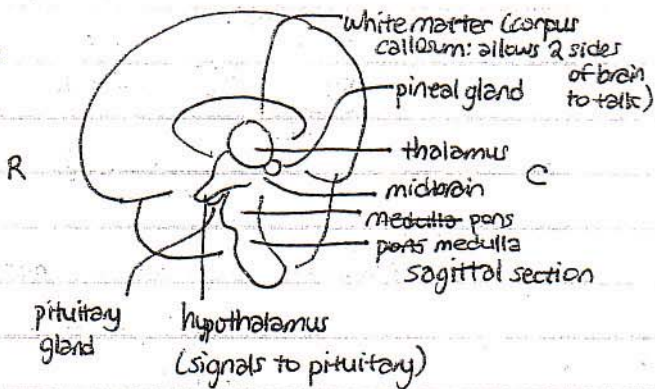- higher cognitive functions

- brain diseases

central sulcus

cerebral hemispheres
telencephalon

longitudinal sulcus (separates hemispheres)

P / F — cortex

T R — lateral sulcus

brainstem

cerebellum

midbrain
pons
medulla } brainstem

spinal cord
(13 spinal nerves)
31

inside: diencephalon

  - thalamus

  - hypothalamus
    ↳ pituitary gland

suprachiasmatic nucleus: circadian rhythms

  - pineal gland (secretes melatonin)

- thalamus — ball-shaped in middle; motor control etc

- hypothalamus — sex drive, eating

white matter (corpus callosum: allows 2 sides of brain to talk)

pineal gland

thalamus

midbrain

medulla pons

pons medulla

sagittal section

R   C

pituitary gland

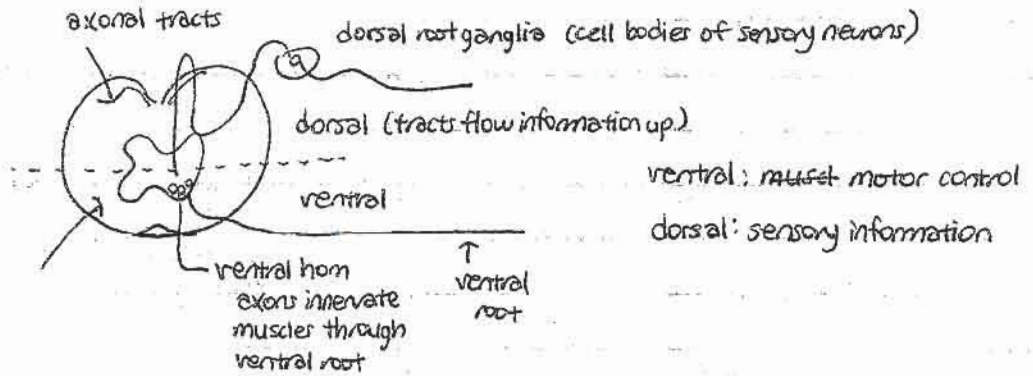hypothalamus (signals to pituitary)

- inside cerebral cortex: (in temporal lobe?)

  - basal ganglia — motor control

    - caudate

    - putamen

    - globus pallidus

  - hippocampus — memory

  - amygdala — emotions

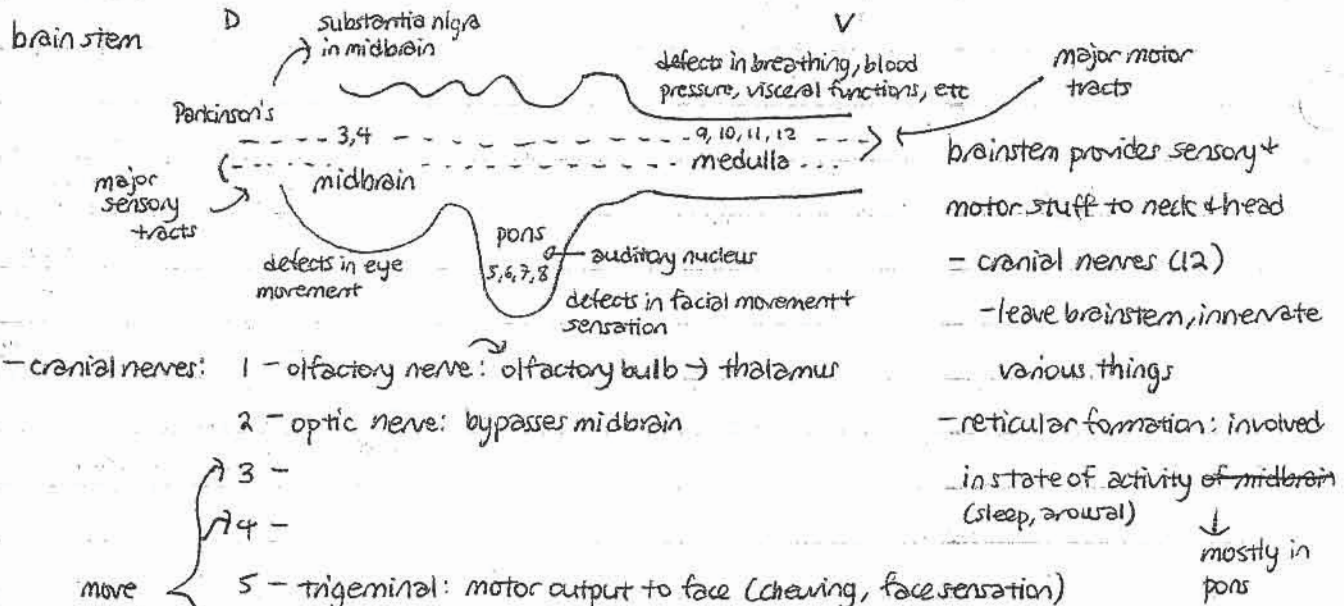peripheral nervous system:

1. somatic — sensation/movement of muscles, skin, etc: dorsal ganglia, near spinal cord

2. autonomic: 1. sympathetic nervous system

        2. parasympathetic " " (counteracts ↑, maintains homeostasis)

          3. enteric nervous system (internal organs)

spinal cord — motor neurons, sensory neurons

axonal tracts

dorsal root ganglia (cell bodies of sensory neurons)

dorsal (tracts flow information up)

ventral

ventral: muscle motor control

dorsal: sensory information

ventral horn
axons innervate
muscles through
ventral root

ventral
root

— 31 spinal nerves (cervical → lumbar)

4 ends at L1 (nerves run down to L5 at bottom)

brain stem

D

substantia nigra
→ in midbrain

V

Parkinson's

defects in breathing, blood
pressure, visceral functions, etc

major motor
tracts

— — 3,4 — — — —

— 9, 10, 11, 12 — — →

major
sensory
tracts

midbrain

medulla

brainstem provides sensory &

motor stuff to neck & head

pons

auditory nucleus

= cranial nerves (12)

5,6,7,8

defects in eye
movement

defects in facial movement +
sensation

— leave brainstem, innervate

various things

— cranial nerves:

1 — olfactory nerve: olfactory bulb → thalamus

— reticular formation: involved

2 — optic nerve: bypasses midbrain

in state of activity of midbrain

3 —

(sleep, arousal)

4 —

↓
mostly in
pons

move
eyes in
different
ways

5 — trigeminal: motor output to face (chewing, face sensation)

6 —

7 — facial nerve: facial expressions, autonomic functions (crying, salivating)

8 — auditory nerve: balance & hearing

9 — glossopharyngeal: tasting, swallowing

* 10 — vagus nerve: output → gut region, controls breathing, heart rate, blood pressure, etc

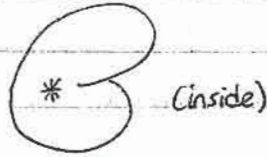11 — spinal accessory nerve: neck muscles (turns head, lifts shoulders)

12 — hypoglossal nerve: tongue movement

cerebellum – coordinates motor behavior, learning of motor tasks
– inputs from spinal cord, ear (balance), cortex (esp. motor cortex)

diencephalon   *⊃ (inside)   1. thalamus
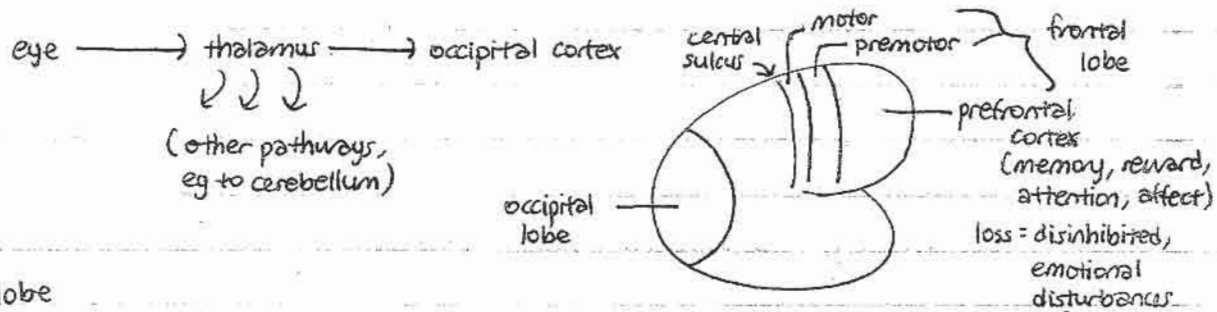   2. hypothalamus

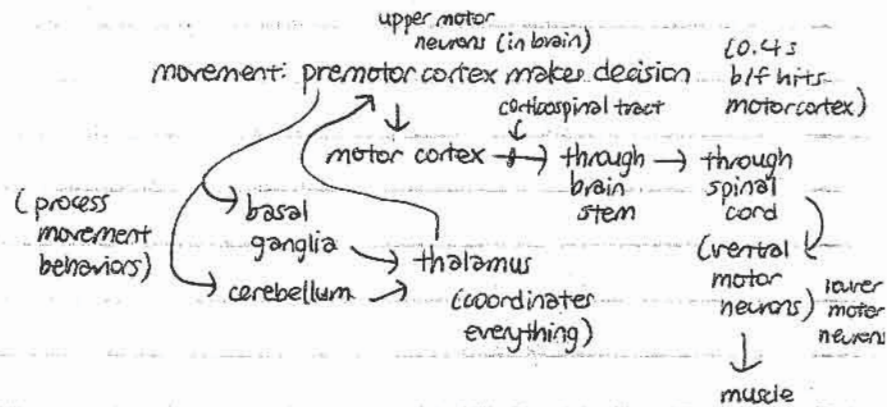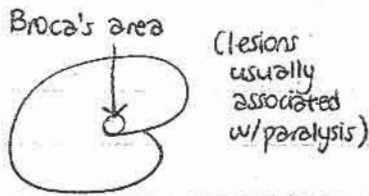– thalamus: many nuclei (lots of sensory & motor inputs, outputs to cortex)
          – big relay station

telencephalon (brain hemispheres)

1. occipital lobe – processes vision : different parts process different vision aspects

eye ⟶ thalamus ⟶ occipital cortex
          ↓ ↓ ↓
     (other pathways,
      eg to cerebellum)

central sulcus ↘   motor — premotor   frontal lobe
occipital lobe   prefrontal cortex
                      (memory, reward, attention, affect)
                      loss = disinhibited, emotional disturbances

2. frontal lobe

– motor output to talking:

Broca's area   (lesions usually associated w/ paralysis)

movement: premotor cortex makes decision   upper motor neurons (in brain)   (0.4s b/f hits motor cortex)
                                corticospinal tract
                        ↓
     (process   motor cortex –↓→ through → through
      movement   brain   spinal
      behaviors)   basal   stem   cord
                    ganglia → thalamus
               cerebellum →   (coordinates   (ventral motor neurons) lower motor neuron
                              everything)
                                            ↓
                                         muscle

– corticospinal tract goes from premotor cortex, decussates
diseases: in medulla in brain stem, down to spinal cord
– upper motor neuron diseases (affect cortex or tract) : spastic, no inhibition of lower pathways
– lower motor neuron diseases: heightened reflexes
                                              large lesions (hemiparesis) on opposite side of body
     – paralysis
– no reflexes, no spasticity, fasciculations (muscles jiggle)
– focal (take out motor + sensory inputs to certain part)

3

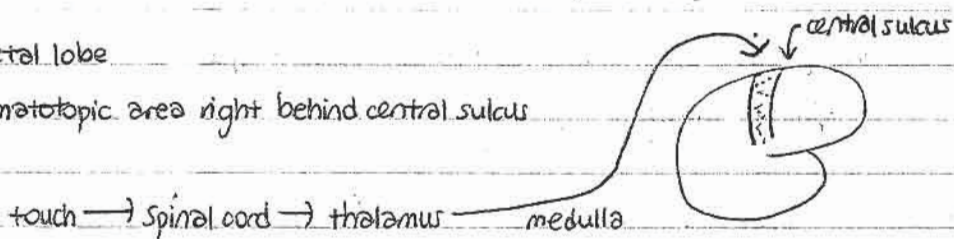- cerebellar diseases
    - get ataxia, tremor
- basal ganglia diseases   (can move, but not on command)
    - Parkinson's disease (dopaminergic neurons from midbrain): hard to initiate movement
    - Huntington's disease (affects caudate): chorea

3. parietal lobe
    - somatotopic area right behind central sulcus

    touch ⟶ spinal cord ⟶ thalamus ⟶ medulla

    - some sensations decussate in spinal cord (pain, eg)
                              in medulla (touch, eg)

4. temporal lobe
    - processing of auditory information, language

    inner ear ⟶ medulla ⟶ pons ⟶ midbrain ⟶ thalamus ⟶ temporal lobe

    Wernicke's area: processing of language (understanding)
                    can talk, but nonsense
                    no recognition of this (terrible prognosis)
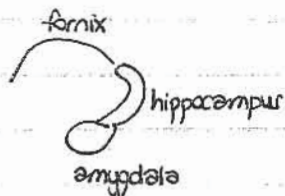   - hippocampus
    - amygdala

- lateral ventricles - holes in brain for cerebrospinal fluid
third bathes thalamus
fourth around cerebellum

4

basal ganglia
- caudate - ~~around p~~ around putamen, follows line of lateral ventricle
- putamen - ball-like

genomics
- humans, yeast, Drosophila, C. elegans (all around 2000-2001) genomes sequenced
  mouse, Arabidopsis
- chop up chromosomes, sequence pieces, use computer to assemble
- human genome: ~30,000 genes
  - repeat sequences account for 50% (transposable elements)
  - only 7% difference between humans & yeast (mostly for multicellular signalling)
  - transposons: LINES
                 SINES

5

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