The Brain
Chapter 14

- Meninges, ventricles, cerebrospinal fluid
- Nervous System Development
- Brain Anatomy
- Higher brain functions
- The cranial nerves
Cranial Meninges (meninx singular)
Meningitis

- Bacterial or viral invasion of the CNS by way of the nose and throat may lead to inflammation of the meninges.
- Pia Mater and Arachnoid are usually affected.
- Signs include high fever, stiff neck, drowsiness and intense headache and may progress to coma.
- Can be diagnosed by examining the CSF.
Cerebral spinal fluid

Infected cerebral spinal fluid

Swollen tissue

Normal meninges

Infected meninges

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Ventricles and Cerebrospinal Fluid (CSF)

- Ventricles are internal chambers within the CNS
  - lateral ventricles found inside cerebral hemispheres
  - third ventricle is single vertical space under corpus callosum
  - cerebral aqueduct runs through midbrain and connects third ventricle and fourth ventricle
  - fourth ventricle is small chamber between pons and cerebellum
  - central canal runs down through spinal cord
- Choroid plexus of capillaries in the ventricles produces the CSF.
- Ventricles are lined with ciliated ependymal cells that circulate the CSF.
- Apertures in fourth ventricle let CSF out of ventricles into subarachnoid space.
Cerebrum
Lateral ventricle
Interventricular foramen
Third ventricle
Cerebral aqueduct
Fourth ventricle
Lateral aperture
Median aperture

(b) Anterior view
Ventricles of the Brain

[Image of a brain with labeled ventricles]
Cerebrospinal Fluid (CSF)

- CSF is a clear liquid that fills ventricles and also bathes the external surface of the brain in the subarachnoid space.
- Brain produces and absorbs about 500 ml/day
  - Produced from filtration of blood through choroid plexus
  - Similar to plasma, but contains no blood cells and less protein than plasma
- Functions
  - buoyancy: brain is neutrally buoyant in CSF so it floats
  - protection: cushions brain from inside of skull
  - chemical stability: provides some ions for the brain and dilutes and washes away metabolic wastes of brain tissue
- CSF is reabsorbed by arachnoid villi into a venous sinus called the superior sagittal sinus which forms from a split in the dura mater
Flow of Cerebrospinal Fluid

1. CSF is secreted by choroid plexus in each lateral ventricle.
2. CSF flows through interventricular foramina into third ventricle.
3. Choroid plexus in third ventricle adds more CSF.
4. CSF flows down cerebral aqueduct to fourth ventricle.
5. Choroid plexus in fourth ventricle adds more CSF.
6. CSF flows out two lateral apertures and one median aperture.
7. CSF fills subarachnoid space and bathes external surfaces of brain and spinal cord.
8. At arachnoid villi, CSF is resorbed into venous blood of dural venous sinuses.
- Ventricles
- Catheter
- CSF flow
- Peritoneal cavity
- Skull
- Burr hole
- Brain tissue
- Shunt to ventricle
Lateral radiograph of the skull shows a typical CSF shunt (arrows). There are also four aneurysm clips (black arrowheads) near the circle of Willis, scalp (skin) staples (white arrowheads), craniotomy fixation plugs (∗), and dental fillings.
Embryonic Development of Nervous System

- Human Nervous System develops from **ectoderm** into a dorsal hollow nerve cord that runs the length of the body.
- In the first 3-4 weeks of development, the **neural plate** on the back of the embryo becomes a **neural groove** with **neural folds** along each side. The neural folds grow together to form the **neural tube**.
- Neurons develop from the cells of the neural tube.
- Lumen of the neural tube develops into the central canal of spinal cord and the ventricles of the brain.
- Cells along the margin of the neural groove are called the **neural crest** and they develop into sensory neurons, sympathetic neurons, Schwann cells and pigment cells.
- By the 4th week, the neural tube develops 3 anterior dilations that will become major brain regions.
Formation of the Embryonic Neural Tube

19 days
Formation of the Embryonic Neural Tube

20 days

Neural groove
Neural crest
Neural fold
Formation of the Embryonic Neural Tube

22 days
Formation of the Embryonic Neural Tube

26 days
Brain Regions

• **Forebrain** develops into four specialized regions:
  – Cerebrum
  – Thalamus
  – Hypothalamus (part of the pituitary gland is an outgrowth of it)
  – Epithalamus (pineal gland)

• **Midbrain**
  – superior and inferior colliculi

• **Hindbrain**
  – Pons
  – Medulla Oblongata
  – Cerebellum

Notes: The **diencephalon** is composed of the thalamus and hypothalamus
The **brainstem** consists of the midbrain, medulla and pons
Regions of Embryonic Nervous System

- Forebrain
- Midbrain
- Hindbrain

(a) 4 weeks
Forebrain
- Telencephalon
- Optic vesicle
- Diencephalon

Midbrain
- Metencephalon
- Myelencephalon

Hindbrain
- Spinal cord

(b) 5 weeks
Telencephalon
Diencephalon
Mesencephalon
Pons
Cerebellum
Myelencephalon (medulla oblongata)
Spinal cord

(c) Fully developed
Diencephalon = thalamus and hypothalamus and pineal gland

Brainstem = midbrain, medulla oblongata, and pons
Hindbrain: Pons, Medulla and Cerebellum

- Pons, medulla and cerebellum make up the “hindbrain”
- The hindbrain is located between the spinal cord and cerebral hemispheres
- Nuclei (clusters of neurons) in these regions control many involuntary, life sustaining processes including respiration, circulation and digestion.
Pons

- Connects cerebrum and cerebellum through the tracts of axons called the cerebellar peduncles
- Nuclei (clusters of neurons) coordinate auditory and vestibular (balance) sensory information with some motor responses.
- Several cranial nerves branch off the pons (V, VI, VII, and VIII)
Medulla

- Formally called the Medulla Oblongata
- Connects the spinal cord to pons
- Contains nuclei that control:
  - Cardiac Center adjusts rate and force of heart beat
  - Vasomotor Center adjusts blood vessel diameter
  - Respiratory Centers control rate and depth of breathing
- Reflex centers for coughing, sneezing, gagging, vomiting, sweating
- Last 4 cranial nerves branch off the medulla oblongata (IX, X, XI, XII)
Cerebellum

- Primary role in skeletal muscle coordination and motor learning
- Also functions in awareness, memory, and emotion.
- Contains about 100 billion neurons including highly dendritic Purkinje cells that integrate information and send information out into a complex network of white matter called the arbor vitae.
Midbrain

• The midbrain is the upper part of the brainstem that connects the forebrain and the hindbrain.

• Important parts of the midbrain include the:
  • superior colliculus
  • inferior colliculus
  • substantia nigra
  • reticular formation
Corpora Quadrigemina: Superior and Inferior Colliculi

- The corpora quadrigemina are 4 nuclei in the midbrain:
  - top two nuclei form the superior colliculus which control visual reflexes like visually track moving objects
  - bottom two nuclei form the inferior colliculus which controls the auditory reflex of turning of the head towards sound
Midbrain nuclei are involved in visual reflexes, auditory relays and motor coordination.

Substantia Nigra uses the inhibitory neurotransmitter dopamine to regulate motor pathways and help control skeletal muscles. Degeneration leads to the tremors of Parkinson disease.
Reticular Formation

- The reticular formation is composed of about 100 nuclei in the brainstem that relay information to the cerebral cortex.
- Some tracts regulate balance and posture.
- Gaze centers allow you to fixate on objects.
- Initiates habituation to repetitive, unimportant stimuli (background noise).
- Regulates sleep and conscious attention.
- Can block pain signals to the brain.
- Damage leads to coma (loss of consciousness).
Thalamus

- Egg-shaped masses of gray matter composed of several nuclei.
- Receives nearly all sensory information on its way to the cerebral cortex then integrates and directs the information to an appropriate area of the brain.
- Interconnected to limbic system so it is also involved in emotion and memory.
• Nuclei in walls and floor of third ventricle
• Homeostatic Functions
  – pituitary gland control
  – autonomic NS control
  – thermoregulation
  – food and water intake (hunger and satiety)
  – sleep/activity rhythms
  – memory (mammillary bodies)
  – emotional behavior (anger aggression, fear, pleasure, contentment, sexuality)
• The Pineal Gland is the main part of the Epithalamus.
• Melatonin produced by pineal gland is involved in activity cycles and in controlling onset of puberty.
Cerebrum is divided into 5 lobes.
The fifth lobe, the Insula, is deep to the lateral sulcus.
Functions of the Lobes of the Cerebrum

- Frontal Lobe: voluntary motor functions and areas for motivation, planning, memory, emotion, social judgment and aggression.
- Parietal Lobe: sensory reception and integration.
- Occipital Lobe: the visual center of brain and creates a visual map of the world.
- Temporal Lobe: contains areas for hearing, smell, learning, memory, visual recognition and emotional behavior.
- Insula functions are still being studied.
Accidental Lobotomy of Phineas Gage

• Accidental destruction of ventromedial region of both frontal lobes changed his personality from a quiet, reliable, hard-working person to an irreverent, profane and fitful person.

• Neuroscientists believe that planning, moral judgement, and emotional control are functions of the prefrontal cortex of the frontal lobe.
Phineas Gage’s life mask and skull
Warren Anatomical Museum
Phineas Gage with the tamping rod that was driven through his head in an accident in 1848
Digital renderings of Gage’s skull showing the trajectory of the rod and the fiber pathways in the left hemisphere. From Van Horn, J. D., et al. (2012).
Connectograms are circular diagrams depicting the brain's major white matter tracts. In these diagrams, the major brain regions - the frontal lobe, insula, limbic system, temporal lobe, parietal lobe, occipital lobe, brain stem and cerebellum - are color-coded and arranged on the outer ring of the diagram, according to their position from the front.

Cerebral White Matter

- White Matter of the brain consists of myelinated axons.
- Most of the volume of the cerebrum is composed of “tracts” of axons (white matter).
- Types of tracts:
  - **projection tracts** extend vertically between brain and spinal cord.
  - **commissural tracts** (like the corpus callosum) cross from one cerebral hemisphere to the other.
  - **association tracts** connect lobes of each hemisphere to each other.
Tracts of Cerebral White Matter

- **Association tracts**
  - Frontal lobe
  - Corpus callosum
  - Temporal lobe

- **Commissural tracts**
  - Lateral ventricle
  - Thalamus
  - Third ventricle
  - Mammillary body
  - Pons
  - Pyramid
  - Medulla oblongata

- **Projection tracts**
  - Basal nuclei
  - Cerebral peduncle
  - Decussation in pyramids

(a)
Cerebral Cortex Gray Matter

- Gray Matter of cerebral cortex is a 3 mm thick layer of neurons.
- Cortex is primarily composed of 2 types of cells in 6 layers:
  - stellate cells have dendrites projecting in all directions
  - pyramidal cells have triangular-shaped somas (pyramidal) and have an axon that passes out of one layer into another area of the brain
basic functional areas

- movement
- sensations
- vision
- judgement
- reward
- memory
- coordination
Functional Regions of Cerebral Cortex

- Primary motor cortex
- Motor association area
- Broca area
- Prefrontal cortex
- Olfactory association area
- Primary somesthetic cortex
- Somesthetic association area
- Primary gustatory cortex
- Wernicke area
- Visual association area
- Primary visual cortex
- Primary auditory area
- Auditory association area
Somesthetic Sensation

- Sensory signals travel up tracts in the spinal cord to the Somatosensory Area which is in the postcentral gyrus of the cerebral hemispheres.
Sensory Homunculus

- The area of the postcentral gyrus of the cerebral cortex dedicated to the sensations of various body parts is proportional to how sensitive that part of the body is.
Sensory Association Areas

- Association areas interpret sensory information.

- Somesthetic Association Area (parietal lobe)
  - position of limbs, location of touch or pain, and shape, weight and texture of an object

- Visual Association Area (occipital and temporal lobes)
  - identify the things we see
  - faces are recognized in temporal lobe

- Auditory Association Area (temporal lobe)
  - remember the name of a song or identify a person by his/her voice
Special Senses

• Special senses are located in the head and employ very specialized sensory receptors.

• Special Senses include:
  – Vision
  – Equilibrium
  – Hearing (auditory)
  – Taste (gustatory)
  – Smell (olfactory)

• These senses are projected to specialized regions of the brain.
Motor Control

- Intention to contract a skeletal muscle begins in the motor association area of frontal lobes and is relayed to the Primary Motor Area.
- The Primary Motor Area consists of Pyramidal Cells in the precentral gyrus.
- Signals are sent out through the spinal cord to muscles of contralateral (opposite) side.
Motor Homunculus

- The area of the cortex dedicated to the motor control of various body parts is proportional to the number of motor units in a region.
Aphasia is a language deficit resulting from lesions in Wernicke’s and Broca’s areas (usually in the left hemisphere).

- Lesion to Broca’s area results in nonfluent aphasia — slow speech, difficulty choosing words, sparse vocabulary.
- Lesions on other side of brain opposite of Broca’s area result in aprosody — flat, emotionless speech.
- Lesion to Wernicke’s area results in fluent aphasia — normal speech but excessively wordy and makes little sense.
- Lesion opposite Wernicke’s area causes difficulty recognizing the emotional content of another person’s speech (for example, not getting a joke).
- Other deficits: speech and understanding speech are normal but text and pictures make no sense.
Language Centers

- Precentral gyrus
- Postcentral gyrus
- Speech center of primary motor cortex
- Angular gyrus
- Primary auditory cortex (in lateral sulcus)
- Broca's area
- Wernicke's area
- Primary visual cortex
People with primary visual agnosia may have one or several impairments in visual recognition without impairment of intelligence, motivation, and/or attention. Vision is almost always intact and the mind is clear. Some affected individuals do not have the ability to recognize familiar objects. They can see objects, but are unable to identify them by sight. However, objects may be identified by touch, sound, and/or smell. For example, affected individuals may not be able to identify a set of keys by sight, but can identify them upon holding them in their hands.

Primary visual agnosia results from damage to the parietal and temporal lobes of the brain. Symptoms develop due to the inability to retrieve information from those damaged areas that are associated with visual memory. Lesions may occur as a result of traumatic brain injury, stroke, tumor, or overexposure to dangerous environmental toxins (e.g., carbon monoxide poisoning). In some cases, the cause of the brain damage may not be known. Symptoms may vary, according to the area of the brain that is affected.
Limbic System

- Loop of cortical structures composed of the amygdala, hippocampus, fornix and cingulate gyrus
- Important in emotional processing and in memory. Much still poorly understood.
Cerebral Lateralization

- **Left** hemisphere is more **categorical**
  - specialized for spoken and written language, sequential and analytical reasoning (math and science), analyze data in linear way

- **Right** hemisphere is more **representational**
  - perceives information more holistically, perception of spatial relationships, pattern, comparison of special senses, imagination and insight, music and artistic skill

- Highly correlated with handedness
  - 91% of right-handed people have a categorical left hemisphere
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"Scout" films of a computed tomographic scan of the head show a nail in the brain of a stuporous, inebriated man seen in the emergency department. Examination revealed a mild right hemiparesis, which persisted after he became sober and fully articulate. Nine hours after admission, the patient disclosed that during a depressive episode 12 years earlier, he had attempted suicide with a nail gun directed between his eyes. Aside from right-sided facial droop and a slight limp, the patient had been symptom-free since the suicide attempt; he had not had either seizures nor episodes of loss of consciousness.
X-ray nails down
the ‘luckiest man’

Associated Press

When the carpenter walked into the emergency room, only the head of the 3-inch nail could be seen against the red inside surface of his lower eyelid. The eyelid was pinned open.

An X-ray and CAT scan revealed that the nail, shot from a co-worker’s nail gun, had missed half a dozen vital areas by an eighth of an inch.

“This has got to be the luckiest guy in the world. He is the luckiest guy in the world,” said Dr. Anne Hayman, a Baylor College of Medicine radiology professor who X-rayed the 56-year-old man last year.

The CAT scan and X-ray images of the extraordinary accident are now being used in medical classes.

The man’s name remains sealed in the records of Ben Taub General Hospital in Houston, though his X-ray was published in today’s New England Journal of Medicine. It and a new feature, an “Images in Clinical Medicine” entry published only on the Internet, can be seen at the journal’s Web site.

The galvanized nail punched through two sinuses, following the path used by brain surgeons to reach the pituitary gland.

It narrowly missed the eye itself, tear ducts, muscles that move the eye, the artery that brings blood to the eye, the carotid artery to the brain, the optic nerve, the pituitary gland, nerves that control eye movement and one controlling feeling and movement of the face.

The nail broke the board it was fired into, but that apparently slowed it down just enough.

“If the nail had continued on, it would have gone through the skull itself and pierced the section of the brain stem that controls heartbeat, respiration and so on,” Hayman said.
A 33-year old male who went to the hospital complaining of a headache was found to have 12 nails embedded in his skull from a suicide attempt with a nail gun. Some of the nails were 1.5” long and others were 2” long and surgeons removed them with needle-nose pliers and a drill. The man at first told doctors he had a nail gun accident, but later admitted it was a suicide attempt while under the influence of methamphetamine. Journal of Neurosurgery April, 2006
A 44-year-old man presented to his local emergency department wearing a baseball cap and complaining of headaches that had progressively worsened over the preceding 11 weeks. After we provided generous analgesia and performed simple investigations that failed to identify a diagnosis, the patient removed his cap to reveal an assortment of metallic objects embedded in his scalp. Plain radiographs showed 11 nails penetrating into his brain. A detailed history revealed a diagnosis of paranoid schizophrenia, and the patient confirmed that he had hammered a nail into his head each week for the past 11 weeks to rid him of evil. The nails were removed with the patient under general anesthesia, and he made an uncomplicated recovery with no neurological deficits.

*We thank Dr Pratipal Kalsi for his help in the care of this patient.*

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Cranial Nerves

- 12 pair of nerves that arise from brain and exit through cranial foramina leading to muscles, glands and sense organs in head and neck
- Learn Number, Name and Function for a matching section on the lab practical.
Cranial Nerves

- Cranial nerves
- Olfactory bulb (from olfactory n., I)
- Optic n. (II)
- Oculomotor n. (III)
- Trochlear n. (IV)
- Trigeminal n. (V)
- Abducens n. (VI)
- Facial n. (VII)
- Vestibulocochlear n. (VIII)
- Glossopharyngeal n. (IX)
- Vagus n. (X)
- Accessory n. (XI)
- Hypoglossal n. (XII)
Language

• Includes reading, writing, speaking and understanding words.

• **Wernicke’s Area** is used to recognize spoken and written language and creates the plan of speech.

• **Angular Gyrus** allows us to read out loud (processes text into a form we can speak). (left hemisphere)

• **Broca’s Area** generates a motor program for the muscles of the larynx, tongue, cheeks and lips and transmits it to the speech center of the primary motor cortex. (left hemisphere)
Reticular Activating System

- Nuclei scattered throughout pons, medulla and midbrain relay information from eyes and ears to cerebral cortex.
- Some tracts regulate balance and posture.
- Gaze centers allow you to track moving objects.
- Initiates habituation to repetitive, unimportant stimuli (background noise).
- Regulates sleep and conscious attention.
- Injury leads to irreversible coma.
Basal Nuclei

- Masses of gray matter deep to cerebral cortex that receive input from substantia nigra and motor cortex and send signals back to these regions.
- Important in motor control.
• Longitudinal fissure separates 2 cerebral hemispheres.

• Surface features:
  • gyri (singular = gyrus) are the raised folds
  • sulci (singular = sulcus) are the grooves in between gyri
Inferior View of the Brain

- Cerebral hemispheres
- Frontal lobe
- Olfactory tracts
- Optic chiasm
- Pituitary gland
- Temporal lobe
- Pons
- Cranial nerves
- Medulla oblongata
- Cerebellum
Median Section of the Brain

- Frontal lobe
- Central sulcus
- Parietal lobe
- Parieto-occipital sulcus
- Corpus callosum
- Thalamus
- Hypothalamus
- Midbrain
- Pons
- Medulla oblongata
- Cerebellum
- Spinal cord
- Occipital lobe
Photo of Sagittal Section of Brain

- Lateral ventricle
- Corpus callosum
- Parieto-occipital sulcus
- Thalamus
- Hypothalamus
- Midbrain
- Pons
- Fourth ventricle
- Cerebellum
- Medulla oblongata
Brain – Directional Terms and Landmarks

• Rostral (toward the forehead) - Caudal (toward the cord)
• Major parts of the brain - cerebrum, cerebellum, brainstem
  – cerebrum is 83% of brain volume; cerebellum contains 50% of the neurons
  – brain weighs 3 to 3.5 pounds
Blood-Brain and Blood-CSF Barriers

• Blood-brain barrier is tightly joined endothelium
  – permeable to lipid-soluble materials (alcohol, O2, CO2, nicotine and anesthetics)
  – circumventricular organs in 3rd & 4th ventricles at breaks in the barrier where blood has direct access
    • monitoring of glucose, pH, osmolarity & other variations
    • allows route for HIV virus to invade the brain

• Blood-CSF barrier at choroid plexus is ependymal cells joined by tight junctions
Olfactory Nerve

- Provides sense of smell
- Damage causes impaired sense of smell
Optic Nerve

- Provides vision
- Damage causes blindness in visual field
Oculomotor Nerve

- Provides some eye movement, opening of eyelid, constriction of pupil, focusing
- Damage causes drooping eyelid, dilated pupil, double vision, difficulty focusing & inability to move eye in certain directions
Trochlear Nerve

- Provides eye movement
- Damage causes double vision & inability to rotate eye inferolaterally
Trigeminal Nerve

- Main sensory nerve to face (touch, pain and temperature) and muscles of mastication
- Damage produces loss of sensation & impaired chewing
Abducens Nerve

- Provides eye movement
- Damage results in inability to rotate eye laterally & at rest eye rotates medially
Facial Nerve

- Provides facial expressions, sense of taste on anterior 2/3’s of tongue, salivary glands and tear, nasal & palatine glands
- Damage produces sagging facial muscles & disturbed sense of taste (missing sweet & salty)
Clinical test: Test anterior 2/3’s of tongue with substances such as sugar, salt, vinegar, and quinine; test response of tear glands to ammonia fumes; test motor functions by asking subject to close eyes, smile, whistle, frown, raise eyebrows, etc.
Vestibulocochlear Nerve

- Provides hearing & sense of balance
- Damage produces deafness, dizziness, nausea, loss of balance & nystagmus
Glossopharyngeal Nerve

- Provides control over swallowing, salivation, gagging, sensations from posterior 1/3 of tongue, control of BP and respiration
- Damage results in loss of bitter & sour taste & impaired swallowing
Vagus Nerve

- Provides swallowing, speech, regulation of viscera
- Damage causes hoarseness or loss of voice, impaired swallowing & fatal if both are cut
Accessory Nerve

- Provides swallowing, head, neck & shoulder movement
- Damage causes impaired head, neck & shoulder movement, head turns towards injured side
Hypoglossal Nerve

- Provides tongue movements of speech, food manipulation & swallowing
- Damage results in inability to protrude tongue if both are damaged or deviation towards injured side & ipsilateral atrophy if one side is damaged
Cranial Nerve Disorders

- **Trigeminal neuralgia (tic douloureux)**
  - recurring episodes of intense stabbing pain in trigeminal nerve area (near mouth or nose)
  - pain triggered by touch, drinking, washing face
  - treatment is cutting of nerve

- **Bell palsy**
  - degenerative disorder of facial nerve
  - paralysis of facial muscles on one side
  - may appear abruptly & disappear within 3-5 weeks
Meninges

• Dura mater -- outermost, tough membrane
  – outer periosteal layer against bone
  – where separated from inner meningeal layer forms dural venous sinususes draining blood from brain
  – supportive structures formed by dura mater
    • falx cerebri, falx cerebelli and tentorium cerebelli
  – epidural space filled with fat in lower back region
    • epidural anaesthesia during childbirth

• Arachnoid mater is spider web filamentous layer

• Pia mater is a thin vascular layer adherent to contours of brain
Ventricles of the Brain

- Lateral ventricles
- Interventricular foramen
- Third ventricle
- Cerebral aqueduct
- Fourth ventricle
- Lateral aperture
- Median aperture

Central canal
Medulla and Pons

Diencephalon
- Thalamus
- Infundibulum

Cranial nerves
- Optic nerve (II)
- Oculomotor nerve (III)
- Trochlear nerve (IV)
- Trigeminal nerve (V)
- Abducens nerve (VI)
- Facial nerve (VII)
- Vestibulocochlear nerve
- Glossopharyngeal nerve
- Vagus nerve (X)
- Accessory nerve (XI)
- Hypoglossal nerve (XII)

Pons

Medulla oblongata
- Pyramid
- Anterior median fissure
- Pyramidal decussation
- Olive

Spinal cord
EEG and Brain Waves

- Electroencephalogram records voltage changes from postsynaptic potentials in cerebral cortex
- Differences in amplitude & frequency distinguish 4 types of brain waves
Brain Waves & Sleep

• States of consciousness can be correlated with EEG

• 4 types of brain waves
  – alpha occur when awake & resting with eyes closed
  – beta occur with eyes open performing mental tasks
  – theta occur during sleep or emotional stress
  – delta occur during deep sleep

• Sleep is temporary state of unconsciousness
  – coma is state of unconsciousness with no possible arousal
  – reticular formation seems to regulate state of alertness
  – suprachiasmatic nucleus acts as biological clock to set our circadian rhythm of sleep and waking
Stages of Sleep

• Non-REM sleep occurs in stages
  – 4 stages occurring in first 30 to 45 minutes of sleep
    • stage 1 is drifting sensation (would claim was not sleeping)
    • stage 2 still easily aroused
    • stage 3 vital signs change -- BP, pulse & breathing rates drop
      – reached in 20 minutes
    • stage 4 is deep sleep -- difficult to arouse
      – seems to have a restorative effect

• REM sleep occurs about 5 times a night
  – rapid eye movements under the eyelids, vital signs increase, EEG resembles awake person, dreams and penile erections occur
  – may help sort & strengthen information from memory
Sleep Stages and Brain Waves

- Brain waves change as we pass through 4 stages of sleep
  - alpha waves
  - sleep spindles
  - theta
  - delta waves
Notice how REM sleep periods become longer and more frequent in the second half of the night.
Cognition

• Cognition is mental processes such as awareness, perception, thinking, knowledge & memory
  – 75% of brain is association areas where integration of sensory & motor information occurs

• Examples of effects of brain lesions
  – parietal lobe -- contralateral neglect syndrome
  – temporal lobe -- agnosia (inability to recognize objects) or prosopagnosia (inability to recognize faces)
  – frontal lobe -- problems with personality (inability to plan & execute appropriate behavior)
Memory

• Information management requires learning, memory & forgetting (eliminating the trivia)
  – pathological inability to forget have trouble with reading comprehension
  – anterograde amnesia -- can not store new data
  – retrograde amnesia -- can not remember old data

• Hippocampus is important in organizing sensory & cognitive information into a memory
  – lesion to it causes inability to form new memories

• Cerebellum helps learn motor skills

• Amygdala important in emotional memory
Emotion

• Prefrontal cortex controls how emotions are expressed (seat of judgement)
• Emotions form in hypothalamus & amygdala
  – artificial stimulation produces fear, anger, pleasure, love, parental affection, etc.
  – electrode in median forebrain bundle in rat or human and a foot pedal
    • press all day to the exclusion of food (report a quiet, relaxed feeling)
• Much of our behavior is learned by rewards and punishments or responses of others to them
PET Scans during a Language Task

1. The word **car** is seen in the visual cortex.
2. Wernicke’s area conceives of the verb **drive** to go with it.
3. Broca’s area compiles a motor program to speak the word **drive**.
4. The primary motor cortex executes the program and the word is spoken.
Functional Regions of Cerebral Cortex
Input and Output to Cerebellum

- Smoothes muscle contractions, maintains muscle tone & posture, coordinates motions of different joints, aids in learning motor skills & coordinates eye movements