

Biopsychology 2012 – sec 003 (Campeau)

Study Guide for Second Midterm Exam

What are the major neuroanatomical relational terms?

- anterior or rostral (synonymous);
- posterior or caudal (synonymous);
- ventral - dorsal
- medial - lateral
- ipsilateral: on the same side;
- contralateral: on the other side;
- bilateral: on both sides.

What are the major information transfer terms used for the nervous system?

- Neural projection describes the route that one area takes to “talk” to another area.
- Track: group of axons traveling together in the central nervous system.
- Nerve: group of axons traveling together in the peripheral nervous system.
- Afferent: “going toward the nervous system”; “coming to”
- Efferent: “going away from the nervous system”

What are the meninges?

They consist of a series of membranes and fluid with the purpose of protecting the brain. From skull to brain, they include:

- Dura mater (closest to the skull);
- arachnoid membrane;
- subarachnoid space (filled with cerebrospinal fluid)
- Pia mater (closest to the brain).

What is cerebrospinal fluid?

Fluid produced by the choroids plexus, which cushions the brain and spinal cord against impact.

How is the nervous system subdivided?

A. Central nervous system:

1. Brain;
2. Spinal cord.

B. Peripheral nervous system:

1. Somatic nervous system:
 - afferent nerves;
 - efferent nerves;
 - some cranial nerves.
2. Autonomic nervous system:
 - afferent nerves;
 - efferent nerves;
 - parasympathetic nervous system;
 - sympathetic nervous system;
 - enteric nervous system;
 - some cranial nerves.

- the neurons of the spinal cord form the gray matter (butterfly shape), with sensory neurons located dorsally (dorsal horns) and motor neurons located ventrally (ventral horns).
- the axons going up and down the spinal cord form the white matter. Most axons carrying sensory information run in the dorsal spinal cord while axons carrying motor information run in the ventral spinal cord (remember what this can tell you if somebody sustains a spinal cord injury!).
- some of the cranial nerves carry somatic information (both sensory and motor).

What are the cranial nerves, and what are their main functions?

The cell bodies of the axons controlling head and neck muscles are located in the brain and they are part of the peripheral nervous system because their axons run outside of the central nervous system (motor cranial nerves – autonomic cranial nerves).

The sensory neurons of the neck and head are located in ganglia outside the brain, but they send their axons to the brain (sensory cranial nerves).

There are 12 cranial nerves:

- I. Olfactory nerve: smell;
- II. Optic nerve: vision;
- III. Oculomotor nerve: eye movement;
- IV. Trochlear nerve: eye movement;
- V. Trigeminal nerve: touch, pain, jaw muscles;
- VI. Abducens nerve: eye movement;
- VII. Facial nerve: facial muscles;
- VIII. Vestibulocochlear nerve: hearing, balance;
- IX. Glossopharyngeal nerve: muscles of throat and larynx, taste;
- X. Vagus nerve: internal organs (autonomic);
- XI. Accessory nerve: neck muscles;
- XII. Hypoglossal nerve: tongue movement.

Note: Mnemonic phrase to help remember order of nerves:

Oh, Oh, Oh, To Touch And Feel Very Good Velvet, Ah, Ha!

How is the brain organized?

Going from most anterior and recent part of the brain on an evolutionary scale:

- I. Forebrain:
 - a. Telencephalon (cerebral cortex, “neocortex”);
 - b. Diencephalon;
- II. Midbrain:
 - a. Mesencephalon;
- III. Hindbrain:
 - a. Metencephalon;
 - b. Myelencephalon

What is the role of the myelencephalon (medulla oblongata)?

It is the origin of several nuclei that give rise to the cranial nerves and it contains the reticular formation, which regulates sleep and wakefulness, skeletal muscle tone, and several vital reflexes (heart rate, blood pressure, respiration, vomiting, etc.).

What is the role of the metencephalon?

It consists of two main parts:

1. the cerebellum, which controls motor coordination, fine motor movements and habit learning (ex. riding a bike); and
2. the pons, which also contain several nuclei of the cranial nerves (especially for hearing and equilibrium), and the pontine reticular formation.

What is the role of the mesencephalon (midbrain)?

It consists of two main parts:

1. the tectum (above the aqueduct), which is involved in auditory information processing (inferior colliculus) and visual information processing (superior colliculus); and
2. the tegmentum (below the aqueduct), which contains the substantia nigra (dopamine producing cells), ventral tegmental area (also produce dopamine), and part of the reticular formation.

What is the role of the diencephalon in the forebrain?

It consists of two main parts:

1. the thalamus (dorsal part), which is an important relay for almost all sensory information before it reaches the cortex; and
2. the hypothalamus (ventral part), which controls many autonomic, motivated (sex, food, drink) and hormonal (master gland) responses.

What is the role of the telencephalon in the forebrain?

It consists of three main parts:

1. the cerebral cortex (neocortex), which is the youngest, most evolved part of the brain; it integrates sensory information, plans responses and controls the peripheral nervous system.
 - the cerebral cortex is further subdivided into:
 - a. frontal lobes: control planning and emotions;
 - b. parietal lobes: control body senses and taste;
 - c. temporal lobes: control learning and memory, hearing, associations and language;
 - d. occipital lobes: control vision.
2. the basal ganglia, consisting of the caudate putamen (striatum), globus pallidus and nucleus accumbens, which are involved in motor control and feedback; and
3. the limbic system, consisting of the medial prefrontal cortex, hippocampus, and amygdala, which are involved in emotions, memory and social responsiveness.

What are the major landmarks on the surface of the brain?

- fissures (major sulci) such as the longitudinal, central, and lateral fissures.
- gyri (bulges) such as the precentral gyrus (primary motor cortex) and postcentral gyrus (primary somatosensory cortex).

Vestibular system:

- What is the difference between the function of the vestibular sacs and the semicircular canals?

Head orientation and gravity detectors vs. head acceleration (not continuous motion), respectively.

- How do the Utricule and Saccule detect head orientation and gravity? Crystals (otoconia) within gelatinous mass induce ciliary movements upon head movement due to gravity.

- How do the semicircular canals detect head acceleration? Endolymph's inertial resistance bends cupula which ultimately produce action potentials in vestibular sensory neurons.

- **What are some of the functions of the vestibular senses?** Upright posture of body and head, balance, motion sickness, vestibulo-ocular reflex and nystagmus.

- **What is the vestibular pathway to the brain?**

- Bipolar sensory neurons receive information from hair cells.
- Sensory neurons are together in vestibular ganglion and their axons give rise to vestibulocochlear nerve (VIII cranial nerve).
- These axons synapse on vestibular nuclei in medulla and cerebellum.
- Axons of vestibular neurons in medulla synapse onto neurons in cerebellum, spinal cord, other medullary nuclei and pons.

Auditory system:

- **How are sound waves generated and propagated?** Anything that sets molecules in motion in a medium (air, water, solids like metals) can generate a sound wave.

- **What are the physical and perceptual dimensions of sound waves?** Amplitudes (intensity), frequency, and complexity, which correspond to loudness, pitch and timbre, respectively.

- **What is the normal range of hearing in humans?** 20 – 20 000 Hertz (Hz, pitch) and about 0 – 160+ decibel (dB, intensity).

- **What are the physical characteristics of our sound organ?**

1. Outer ear: -pinna
-ear canal
-external eardrum (tympanic membrane)
2. Middle ear: -internal eardrum
-ossicles: malleus (hammer)
incus (anvil)
stapes (stirrup)
3. Inner ear (cochlea): -oval window
-round window
-endolymph
-cochlear duct – Organ of Corti, which contains main auditory receptor apparatus
-tectorial membrane (rigid, where cilia of hair cells are “stuck”)
-basilar membrane (moves according to sound waves)
-hair cells – involved in transduction of wave energy to sound

- **How does sound of different frequencies get coded in cochlea?** Vibrating basilar membrane at different “places” along cochlea respond to high frequency (base of membrane – closest to oval window) and successively lower frequency as moving toward Apex of membrane = Place coding. Low frequency (< 200 Hz) are coded by vibration of basilar membrane over a large portion of its length = frequency of action potentials produced by hair cells = Rate coding.

- **How is sound localized by the auditory system?**

1. Difference in arrival time of sound waves between two ears.
2. Intensity differences of sound waves between two ears (works best with high frequencies).

3. Phase differences in the sound waves reaching the two ears (for lower frequencies).

- Direction of low frequencies (< 100 Hz) are virtually impossible to detect.

- What is the auditory pathway to the brain?

- Bipolar sensory neurons receive inputs from auditory hair cells.
- Auditory neurons are together in spiral ganglion and give rise to auditory nerve (part of vestibulocochlear nerve, VIII cranial nerve) which synapse on cochlear nuclei in medulla.
- Don't need to know all the connections in medulla and pons (trapezoid body, superior olivary complex, etc), but remember that most information cross to the other side of the brain at this level. Why is this important (hint: sound localization and sound intensity).
- Know that inputs from medulla and pons reach Inferior colliculus (midbrain tectum).
- Inferior colliculus send axons to medial geniculate body.
- Medial geniculate body send axons to Auditory cortex in a topographical orientation (organized in cortex from low -anterior; to high - posterior; frequencies).
- Are there particular functions performed by the left vs. right auditory cortex? (check the language section and emotion section pp 319-320 and 324-335 of your textbook).

Visual system:

- **What is light?** Electromagnetic energy in a relatively narrow band of a continuum ranging from Gamma rays to AC circuits; its wavelength is measured in nanometers.

- What are the 3 perceived characteristics of light?

1. Hue, corresponding to the spectrum (wavelength) of light.
2. Brightness, corresponding to intensity of wavelength.
3. Saturation, corresponding to the purity of wavelength.

- **What are the physical characteristics of the eye?** Know the major components of the eye such as the sclera, cornea, iris, pupil, lens, ligament, ciliary muscles, retina, blind spot, optic nerve and fovea.

- **How is the retina organized?** Photoreceptors (rods and cones) are in the deepest level of the retina, followed by bipolar cells, and ganglion cells, which are closest to where light enters the eye.

- What produces some of the abnormalities of vision?

- Nearsightedness: eyeball too long.
- Farsightedness: eyeball too short.
- Astigmatism: uneven cornea/lens.

What is the mechanism of transduction of light into nerve impulse?

- Light hits photoreceptors – bleaches rhodopsin molecules that “splits” into retinal;
- Retinal activates transducin;
- Transducin in turn activates phosphodiesterase;
- Phosphodiesterase destroys cGMP;
- cGMP destruction closes the cationic channels (channels that let Na⁺ and Ca⁺⁺ inside the receptors);
- This hyperpolarizes the photoreceptor's membrane.

- How is information transmitted in the retina?

Photoreceptors (no action potentials) to bipolar neurons (no action potentials) to retinal ganglion neurons (first cells to produce action potentials) which send their axons to the brain via optic nerve.

- What are the mechanisms of central vs. peripheral acuity?

Receptive field in center of retina = fovea

- provides clear, precise color vision;
- mostly populated by cones;
- little convergence onto ganglion cells (not very sensitive).

Receptive field outside of fovea = periphery

- provides fuzzy, imprecise black and white vision;
- mostly populated by rods;
- high degree of convergence onto ganglion cells (very sensitive to even dim light).

- What is the visual pathway to the brain?

Ganglion cells provide axons of optic nerve.

Optic nerve decussates (nasal hemi-retina) to contralateral brain.

Optic tract axons innervate cells of the lateral geniculate nucleus.

From the lateral geniculate nucleus, axons project to the occipital cortex (visual cortex – V1).

Some axons of ganglion cells also project to hypothalamus (suprachiasmatic nucleus – daily rhythms) and superior colliculus (eye and head reflexes toward visual stimuli moving in peripheral vision).

- What is the mechanism of color vision?

Trichromatic theory (Young) = Three types of cones, the relative intensity of which produce color perception (true at photoreceptor level).

Opponent process theory (Hering) = Opponent colors “linked” together.

Red-green opponents

Blue-yellow opponents

Black-white opponents

Color perception due to relative activity of these 3 types of opponent systems

True at the level of ganglion cells and in the rest of the visual system after (i.e., geniculate and cortex)

- How do opponents work?

Review visual receptive field concept; opponent colors are perceived, respectively by the center and surround fields of a ganglion cell - for example, red illumination in the center field of one ganglion cell will increase its activity, but green illumination on its surround field will inhibit the same ganglion cell's activity. The situation can be reversed (red center inhibitory, green surround excitatory, etc.), and similar for the other opponents.

- How does the visual system enhance edges and increase contrast?

Based on firing rate of ganglion cells, which is proportional to light intensity;

Ganglion cells inhibit their neighbors = lateral inhibition;

Lead to phenomena such as Mach bands

- **What are visual receptive fields?** Area of visual field in retina within which it is possible for a visual stimulus to influence the firing of a given neuron.
 - Receptive fields in retino-geniculate-cortical (layer IVc) pathway are circular.
 - Simple cortical cells (outside of layer IVc in visual cortex) have linear or rectangular receptive fields that respond best to orientation, with antagonistic “on” and “off” receptive fields, from one eye (monocular)
 - Complex cortical cells (similar to simple cortical cells with the following differences)
 - larger receptive fields;
 - less static, respond better to moving lines or rectangles;
 - show responses to both eyes (binocular)

Chemical senses:

- **What are the chemical senses?** Smell and taste are chemical senses because their function is to monitor chemical content (volatile substances for smell, dissolved substances for taste) of the environment.

- **What are the different taste “qualities” in humans?**

There are only 4 qualities: bitterness, sourness, sweetness and saltiness.

- **Where are the taste receptors located?** On the tongue, palate, pharynx and larynx.

- **How are the taste receptors organized?**

There are about 10 000 taste buds, each containing from 20-50 receptor cells, arranged like the segments of an orange.

The receptors send cilia into opening of papilla, where food chemicals can bind when dissolved into saliva. Binding produces receptor potentials that are conveyed to the brain.

Different areas of the tongue contain the receptors for the different taste qualities.

- **What is the gustatory pathway to the brain?**

-inputs from three sensory cranial nerves (facial, glossopharyngeal, and vagus) which receive synaptic inputs from taste receptors send their axons to the nucleus of the solitary tract.

-neurons of the nucleus of the solitary tract send their axons to the lateral hypothalamus, amygdala and ventral posteromedial thalamus.

-neurons in the thalamus send axons to the primary gustatory cortex.

-some neurons of primary gustatory cortex send axons to the orbitofrontal cortex.

- **Where are the olfactory receptors located?** In the roof of the nasal cavity, in the olfactory epithelium.

- **How are olfactory receptors organized?**

There are over 1000 different olfactory receptors, any one of which is contained in cilia of olfactory neurons.

The cilia are in contact with the mucus of the olfactory epithelium and bind the dissolved volatile substances.

Olfactory neurons contact mitral neurons in the olfactory bulb via the short axons of the olfactory nerve (Ist nerve)

- What is the olfactory pathway to the brain?

Olfactory neurons to mitral cells.

Mitral cells of olfactory bulb to piriform and entorhinal cortex (primary olfactory cortex) and amygdala.

Amygdala to medial dorsal thalamus.

Medial dorsal thalamus to orbitofrontal cortex (involved in conscious perception of flavor).