NBL 356 FStoCNS Module 6 Review Q&A

*1. List the major components of the visual system and the function of each component. The human visual system is especially good at detecting \_\_\_\_\_\_, whether it be chromatic, luminance or timing, allowing the brain to perceive color, edges, shadows, depth and motion.*

The major components of the visual system are the eye (retina), optic nerve, optic chiasm, optic tract, LGN of the thalamus, optic radiation, primary visual cortex, and other regions of visual cortex. Light information from the optic tract also goes to the superior colliculus in the midbrain and to the SCN of the hypothalamus. The eye contains the light detectors (photoreceptors), the optic nerve and optic tract contain the axons that transmit the AP signals to the thalamus, the thalamus relays the visual information via APs to the primary visual cortex, the primary and association visual cortices receive and integrate the visual information into perception. The human visual system is especially good at detecting contrast, whether it be chromatic, luminance or timing, allowing the brain to perceive color, edges, shadows, depth and motion.

*2. What type of energy is visible light? What wavelength range can the human retina detect? What is one hypothesis about why the mammalian retina evolved to detect only in this range? What do the lens and cornea do? How are visual coordinates mapped from visual space onto the retinal surface?*

Light is electromagnetic energy. The cornea is the outermost part and it focuses the light onto the eye by refraction. The lens also focus light and changes the focal distance of the eye. Mammalian eyes probably evolved to detect electromagnetic radiation in the visible spectrum (380-720 nm) because the majority of solar radiation that arrives on the earth surface is in the visible range, and most objects we interact with on earth reflects or absorbs light in this spectrum. If you see something in your left visual field, the temporal right hemiretina and left nasal hemiretina will detect it and information travels along axons in the right optic tract to the right thalamus. In the right visual field, the temporal left hemiretina and right nasal retina will detect it and information will travel along axons in the left optic tract to the left thalamus.

*3. What are the five basic retinal cell types and how is the retina organized? What do nuclear layers and plexiform layers in the retina contain? The output from retinal ganglion cells via their axons is \_\_\_\_\_. What do the RCG axons form, and in what brain areas do RGCs axons synapse?*

From deep to superficial, there are optic nerve fibers (axons), retinal ganglion cells (RGC), amacrine cells, bipolar cells, horizontal cells, rod and cone photoreceptor cells, and pigmented epithelium. (Photoreceptors are located on the outermost part of the retina, next to bipolar cells, while ganglion cells in the innermost parts. Light travels through all the layers to reach the photoreceptor cells.) The output from RGCs is action potentials along their axons that form the optic nerve. In contrast, all synapses between photoreceptor, bipolar, horizontal, and amacrine cells, and from bipolar to RGCs involve graded potentials. RGC axons form the optic nerve, which synapses in the lateral geniculate nucleus (LGN) in the thalamus. Action potentials of RGCs are conducted along the optic nerve and optic tract. The majority of RGC axons synapse on neurons in the LGN of the thalamus. In addition, RGC axons also synapse in the midbrain superior colliculus, and the hypothalamus in the suprachiasmatic nucleus (SCN).

*4. What type of photoreceptor occupies the central fovea? Where are rods located? What are the main three morphological regions of the photoreceptor cell and what is the function of each region?*

Cones occupy the fovea (L and M cones in central fovea, S cones not found in the very center of the fovea). Cones are also located at a much lower density in the periphery. Rods are located in the periphery, with a highest density at approximately 20 degrees visual angle.

The three regions of the photoreceptor cell include: Outer segment-detect photons and mediate phototransduction; inner segment-mitochondria and nucleus, protein synthesis; and synapses- where photoreceptors communicate with bipolar and horizontal cells.

*5. What is the basis of the “dark current” in the photoreceptor cells? What effect does the dark current have on the membrane potential, and neurotransmitter release? What neurotransmitter is released?*

In the dark (in the absence of photons), photoreceptor cells are depolarized to about -40 mv. The reason for this is because they have normal K+ leak channels in the inner segment, and K+ ion outflow establish the RMP. In addition however, in the dark, the levels of cyclic GMP are high in the outer segment; cyclic GMP opens the cGMP-gated channel (cGGC) a nonselective cation channel and keeps them open, so there is a constant influx of Na+ and Ca2+ into the outer segment, which depolarizes the membrane potential to about -40 mV. The dark current keeps the photoreceptors depolarized, which keeps the voltage-gated Ca2+ channels (VGCC) open at the presynaptic region, and glutamate is constantly released in the dark.

*6. Describe the phototransduction process from when a photon of light strikes a photoreceptor cell to its (photoreceptor) synaptic output. What is the purpose of the membrane discs in the outer segments? How can rhodopsin, transducin and PDE be located on intracellular disc membranes and still function?*

As describe above, in the dark the membrane is depolarized to about -40 mV and glutamate is constantly released. A photon of light will strike a rod or cone in its outer segment, which is where rhodopsin/cone photopsin is. Rhodopsin is formed from the covalent binding of opsin to retinal. In the presence of light, a photon is absorbed and the 11-cis retinal breaks its double bond, allowing for free rotation. This triggers a conformational change in the opsin protein. In the absence of light, transducin (a G protein) is bound to GDP. The activation of rhodopsin leads to the activation of transducin. The transducin alpha subunit releases GDP, so GTP can bind, activating transducin. Transducin-GTP activates phosphodiesterase (PDE) in the disc membrane, which hydrolyzes cyclic GMP (cGMP) to 5’GMP, and this decreases the concentration of cGMP throughout the outer segment. As the cGMP levels decrease, this leads to closing of the cGMP-gated channels (cGGC), which hyperpolarizes the membrane potential. Thus in the light, closing of the cGMP-gated channels (cGGC) leads to hyperpolarization to about -65 to -70 mV, and less glutamate is released.

The discs are where rhodopsin, transducin and PDE are located. These discs are intracellular ER-like membranes, which increase the surface area for rhodopsin location and the signaling cascade leading to light dependent hydrolysis of cGMP. A photon can pass directly through the outer segment plasma membrane, so it can activate rhodopsin in the intracellular membrane (which is why they can still work inside the cell). There is disc shedding by phagocytosis by the RPE cells. (From Wikipedia: in cone cells, there are different types of opsins that combine with retinal to form pigments called photopsins (which are analogous to rhodopsin). Three different classes of photopsins in the cones (S, M, L) have sensitivity to different wavelengths of light.

Rhodopsin, transducin and PDE are all located within/on the disc membrane, which is found entirely inside the neuron. But that’s ok because light, the stimulus, is able to pass directly through the plasma membrane and be absorbed by the retinal in rhodopsin. The rhodopsin needs to be on the same membrane as transducin and PDE, because it activates the transducin, which then activates PDE. The cGMP is a small hydrophilic messenger that can diffuse quickly, and its target, the cGGC is located on the plasma membrane.

*7. Thinking about the response to light, one might speculate that the stimulus for the retina is actually the absence of light (darkness) on a background of light. Explain.*

In most sensory systems, detection and transduction of the stimulus leads to a depolarizing receptor potential response. However in the visual system, in the dark the membrane is depolarized and in the light, the photoreceptor membrane becomes hyperpolarized to about -65-70mV (similar to the resting membrane potential in an unstimulated neuron). If one thinks about the stimulus as being a lack of light: then a photoreceptor (in the light) detects an area of darkness in the receptive field (an absence of photons), then cGMP levels are increased, activates the cGGC, which depolarizes the membrane potential and increases glutamate release.

*8. In photoreceptor cells (rods and cones), the response to light is always \_\_\_\_\_\_\_\_\_ that results in a \_\_\_\_\_\_\_\_ in \_\_\_\_\_\_\_\_release at synapses onto \_\_\_\_\_\_ and \_\_\_\_\_\_\_\_cells.*

In photoreceptor cells (rods and cones), the response to light is always hyperpolarization that results in a decrease in glutamate release at synapses onto bipolar and horizontal cells.

*9. What are two mechanisms for light adaptation (at the level of photoreceptors)?*

A. Activation of rhodopsin (by light) leads to phosphorylation of rhodopsin by rhodopsin kinase, then arrestin can bind to the phospho-rhodopsin which prevents rhodopsin from activating any more transducins. B. After rhodopsin stimulates the alpha subunit of transducin to bind GTP (which activates it), transducin-GTP can activate PDE. However, transducin alpha also has an intrinsic GTPase activity that hydrolyzes the bound GTP to GDP. Transducin alpha-GDP is inactive and it also reassociates with the beta-gamma subunits, which together switch off transducin.

*10. How are rods and cones similar, how are they different?*

Location in retina: Cones occupy the fovea (L and M cones in central fovea, S cones not found in the very center of the fovea). Cones are also found outside the fovea. Rods are absent from the fovea. Rods are located in the periphery, with a highest density at approximately 20 degrees visual angle.

Similarities: Both are photoreceptor cells that detect light. Both express opsins/photopigments (rod opsin is called rhodopsin while cone opsins are called phototpsins) and both use the same phototransduction cascade (leading to a decrease in cGMP) with the effect being the closing of the cGMP gated channels on the disc outer segment membrane, hyperpolarization of the membrane potential and a decrease in glutamate release in response to light. Both can synapse on bipolar cells, and on horizontal cells.

Differences: Cones express three pigments (photopsins), and are for color and high acuity vision at medium to bright light levels (photopic vision). Rods express only one pigment (rhodopsin) and are for vision at low light levels (scotopic vision). Cones have lower sensitivity to light but faster temporal responses, function in bright light and don’t saturate, and are for day vision. Rods have higher sensitivity to light but slower temporal responses, function in dim light and saturate in bright light, so are for night vision. There are more rods than cones. Rods have separate internal discs in the outer segment (so the transduction cascade occurs on intracellular membrane), cones have fused discs in the outer segment which are part of the plasma membrane (so the transduction cascade in on the disc plasma membrane). They connect to different types of bipolar cells.

*11. What are the functions of the retinal pigmented epithelial cells? In what two ways could they protect the photoreceptor cells? What disease is loss of RPEs involved?*

RPEs nourish photoreceptor cells, and phagocytose damaged portions of the membrane of the outer segment of photoreceptors. They are also able to absorb photons because of their pigment, which reduces light scattering, enhancing acuity, and protecting photoreceptor cells from further damage by photons. RPE atrophy has been linked to pathogenesis of age-related macular degeneration (AMD), a leading cause of blindness in elderly in the USA.

*12. All bipolar and retinal ganglion cells have a receptive field that includes a center and surround. What are the center and surround? Describe the on center/off surround and off center/on surround visual field.*

From Wikipedia: “The receptive field of an individual sensory neuron is the particular region of the sensory space (e.g., the visual field) in which a stimulus will modify the firing of that neuron. In the visual system, receptive fields are volumes in visual space. The receptive field is often identified as the region of the retina where the action of light alters the firing of the neuron.” For bipolar cells and retinal ganglion cells (RGCs), the receptive field has two regions, a center and surround, and there are two types of bipolar and RGCs. The on-center (off-surround) bipolar cell is depolarized when light is exposed to the center and hyperpolarized when light is exposed to the surround. The on-center (off-surround) RGC increases AP frequency when light is exposed to the center and decreases AP frequency when light is exposed to the surround. The off-center (on-surround) bipolar cell is hyperpolarized when light is present in the center and depolarized when light is present in the surround. The off-center (on-surround) RGC decreases AP frequency when light is exposed to the center, and increases AP frequency when light is exposed to the surround.

*13.What is the purpose of having on center and off center bipolar cells (and RGCs)?*

The two types of both bipolar cells and RGCs are on-center/off-surround, and off-center/on-surround. We need two different types of bipolar and RG cells to provide maximal contrast to both light and dark, which is important to be able to distinguish boundaries, object edges, shadows, the movement of objects and also for color. (Off RGCs respond (increase APs) to the absence of light in the center-which allows us to detect dark objects (the absence of reflected light) on a light background.) Contrast is the main output of RGCs because of lateral inhibition provided by the horizontal and amacrine cells. Three features of the main output signals from the eye are that they arise from retinal ganglion cells, each class of ganglion sends different information about the visual world, and the primary output signal is a form of contrast based on either luminance, wavelength, or timing.

*14.Cone photoreceptor cells synapse onto “on bipolar” and/or “off bipolar” cells. Explain how sign conservation and inversion can occur with the same neurotransmitter. In other words, how does an increase in light (decrease in glutamate) from the photoreceptor cell lead to hyperpolarization of “off bipolar” cells while an increase in light (decrease in glutamate) from the photoreceptor cell lead to a depolarization of “on bipolar” cells? Be specific about receptors. Describe the on and off bipolar and on and off retinal ganglion cells responses.*

There are on-center (off-surround) and off-center (on surround) bipolar cells (and retinal ganglion cells (RGCs). On-center bipolar cells depolarize in response to light in the center. They synapse onto on-center retinal ganglion cells, which increase AP firing in response to light in the center. The off center bipolar cells hyperpolarize in response to light in the center. They synapse onto off center ganglion cells, which decrease AP firing in response to light in the center.

• Photoreceptors release glutamate onto both types of the bipolar cells. In both synapses an increase in light in the receptive field center leads to hyperpolarization of the photoreceptor and this leads to a decrease in glutamate release.

• Bipolar cells express different types of receptors that lead to different responses. “On bipolar” cells express mGluR6 receptors (G-protein coupled receptors). In the dark, high glutamate hyperpolarizes the on bipolar cell (through G-protein-TRP channel inhibition). In the light, a decrease in glutamate leads to a depolarization of the on bipolar cell (by decreasing the G protein inhibition of TRP channels). This is a sign inversion.

• “Off bipolar” cells express AMPA receptors (ionotropic) receptors. In the dark, high glutamate depolarizes the off bipolar cell via activation of AMPRs.) In the light, a decrease in glutamate leads to a hyperpolarization of the off bipolar cell. This is a sign conservation.

*15. Briefly describe the vertical (direct) and lateral (indirect) processing pathways. Where are horizontal cells located, what do they synapse on, what do they do and why are they important? What do center surround receptive fields provide? What does it mean that contrast is the main output signal of retinal ganglion cells?*

Vertical (direct) pathway: photoreceptor cell to bipolar cell to retinal ganglion cell. The wiring can be one to one, divergent or convergent from photoreceptor to bipolar. For bipolar to RGCs the wiring is usually either one to one or convergent. (There are fewer RGCs than photoreceptor or bipolar cells.) Lateral (indirect) pathways: 1) photoreceptor to horizontal cell, horizontal cell to bipolar cell and feedback to photoreceptor cells; 2) bipolar cell to amacrine cell, amacrine cell to RGC and feedback to bipolar cell. As described above, center surround receptive fields provide contrast (from Wiki: “The center-surround receptive field organization allows ganglion cells to transmit information not merely about whether photoreceptor cells are exposed to light, but also about the comparison in light between the center and surround. This allows them to transmit information about contrast.”) Lateral (indirect) processing pathways through horizontal cells and amacrine cells play a key roles for the comparison between the center and surround. .

*16. How can the visual system detect light over a luminance range of 9-10 orders of magnitude? (There are four main mechanisms.)*

A. Dilation of the pupil. (The pupil ranges in diameter from about 2 mm to 8 mm. This factor of 4 means that the amount of light entering the eye ranges over a factor of 16, or about one order of magnitude.)

B. Rods and Cones. We essentially have two visual systems in the eye with very different luminance sensitivities.

C. Rods and Cones adapt. Both rods and cones become less sensitive as light levels increase. This occurs at the level of adaptation of the phototransduction cascade.

D. Horizontal cells provide inhibitory feedback to rods and cones.

*17.What is distinctive about retinal ganglion cells and what are the features of the output from RGCs? What is the response of an on center-off surround RGC to light in the center, light in the surround, and light in both? What is the response of an off center-on surround RGC to light in the center, light in the surround, and light in both?*

RGCs receive information from bipolar cells and amacrine cells. RGCs are glutamatergic neurons that have axons, which form the optic nerve and then the optic tract. The action potentials that are generated and conducted by the RGC axons represent the only output from the retina. There are three main types of RGC cells, now called M, P and K type cells, which are specialized to transmit different types of visual information. All RGCs have a low intrinsic rate of AP firing in the dark. On center cells fire more action potentials in response to light in the center of the receptive field, fire fewer APs when light is on the surround, and fire even less if both the center and surround are illuminated. Off center cells fire more APs in response to light in the surround, and fewer APs when the center is illuminated, and even less when both the center and surround are illuminated. The rate of APs in response to illumination is dependent on the intensity of light and area that is illuminated.

*18.What is the function of cones? Why does it take at least two different cones to perceive color? Explain what is being compared (and by what) to detect color. Be prepared to draw this in a diagram.*

Cones are responsible for photopic vision, high acuity vision, and color vision. Cones express one of three different photopigments (cone photopsins) that absorb light with different wavelength maxima in the red (L), green (M) or blue (S) wavelengths. Thus, light at any wavelength will excite at least two of the cone types, and often three. Perception allows us to determine color by comparing the different responses that each type of cone produces at a given wavelength. So, there has to be at least two cones/photopigments to do this comparison. With two cones/photopigments, the activation of both cones can be compared – only one wavelength will trigger those specific cone responses in a particular combination. (If you only had one photopigment/cone, there are two possible wavelengths for each level of response because it is a curve (parabola). When you add a second photopigment/cone, it allows you to determine which of the two wavelengths it is by cross-referencing (comparing) the responses of the first photopigment/cone with that of the second photopigment/cone.)

*19.What are the optic nerve and optic tract (what forms them and where do they originate)? What are the three main brain regions that the optic tract sends information to and what is the purpose of each?*

The optic nerve emerges from the retina and contains RGC axons. There are about 1.2 million RCG axons in each optic nerve. The optic nerve is a cranial nerve, which transmits action potentials from the eyes (retina) to the brain. The optic nerve is the bundle of axons from the RGCs that project to and about half cross at the optic chiasm, and are reformed into the optic tract. The optic tract includes axons from ipsilateral and contralateral RGCs and that project to the LGN of the thalamus, the pretectum, superior colliculus, and the suprachiasmatic nucleus (SCN) in the hypothalamus. The thalamus relays the information for visual perception, including image construction, color and movement. The pretectum and superior colliculus relays visual information to control pupil constriction/dilation (pretectum) and specific eye movements (superior colliculus). The SCN is where our circadian rhythms involving the day-night cycle are generated.

*20.What are photosensitive retinal ganglion cells? Describe the non-thalamic targets of the optic tract.*

From Wikipedia: Photosensitive ganglion cells, including but not limited to the giant retinal ganglion cells, contain their own photopigment, melanopsin, which makes them respond directly to light even in the absence of rods and cones. They project to the suprachiasmatic nucleus (SCN) in the hypothalamus, and to the pretectum and superior colliculus in the midbrain.

Pretectum: The pupillary light reflex is mediated by the pretectum. This reflex is responsible for the constriction of the pupils upon light's entering the eye. Parts of the pretectum are also implicated in the accommodation reflex by which the eye maintains focus.

Superior colliculus: From Wiki: “In primates, eye movements can be divided into several types: fixation, in which the eyes are directed toward a motionless object, with eye movements only to compensate for movements of the head; smooth pursuit, in which the eyes move steadily to track a moving object; saccades, in which the eyes move very rapidly from one location to another; and vergence, in which the eyes move simultaneously in opposite directions to obtain or maintain single binocular vision. The superior colliculus is involved in all of these, but its role in saccades has been studied most intensively.”

Hypothalamus: “The suprachiasmatic nucleus or nuclei (SCN) is a tiny region of the brain in the hypothalamus, situated directly above the optic chiasm. It is responsible for controlling circadian rhythms.” “The SCN receives input from specialized photosensitive ganglion cells in the retina via the retinohypothalamic tract.” “Many aspects of mammalian behavior and physiology show circadian rhythmicity, including sleep, physical activity, alertness, hormone levels, body temperature, immune function, and digestive activity. The SCN coordinates these rhythms across the entire body.”

*21.Briefly describe the three classes of RGC cells (P, M and K type) and their distinguishing characteristics.*

Classes of RGC neurons:

P-type – Project to the parvocellular layers in LGN (top 4 layers of LGN)

Most numerous type

Smaller cells

Low temporal frequency but sustained responses

Chromatic

High spatial frequency

M-type – Project to the magnocellular layers in LGN (bottom 2 layers of LGN)

Less numerous type

Larger cells

Receptive fields not sensitive to color (achromatic)

Sensitive to low contrast

High temporal frequency and transient responses

K-type – Project to koniocellualar layers in LGN (that lie between parvocellular and magnocellular layers)

Less numerous type

Small cells

Mixed spatiotemporal responses

Chromatic-S-cone dominant

Receptive fields of the LGN neurons inherit the center-surround receptive field from their RGCs.

*22.Describe the LGN in the thalamus.*

From Wikipedia: “The lateral geniculate nucleus (LGN) is a relay center in the thalamus for the visual pathway. It receives a major sensory input from the retina. The LGN is the main central connection for the optic nerve and tract to the occipital lobe, particularly the primary visual cortex. In humans, each LGN has six layers of neurons (grey matter) alternating with optic fibers (white matter).” Both the left and right hemisphere of the brain have a lateral geniculate nucleus, named after its resemblance to a bent knee (genu is Latin for "knee" as in genuflect). In humans as well as in many other primates, the LGN has layers of magnocellular cells and parvocellular cells that are interleaved with layers of koniocellular cells. In humans the LGN is normally described as having six distinctive layers. The inner two layers, (1 and 2) are magnocellular layers, while the outer four layers, (3,4,5 and 6), are parvocellular layers. The koniocellular layers, are found ventral to each of the magnocellular and parvocellular layers.” “The magnocellular, parvocellular, and koniocellular layers of the LGN correspond with the similarly named types of retinal ganglion cells.” Both the LGN in the right hemisphere and the LGN in the left hemisphere receive input from each eye. However, each LGN only receives information from one half of the visual field. The eye on the same side (the *ipsilateral* eye) sends information to layers 2, 3 and 5. The eye on the opposite side (the *contralateral* eye) sends information to layers 1, 4 and 6.”

*23. What is the optic radiation? What is V1 and where is it located? What are its other names? What layers of V1 receive input from the LGN, which LGN cells connect to which cortical layers? How is information integrated in V1?*

The optic radiation is the bundles of myelinated axons that project from the neurons in the LGN of the thalamus to the primary visual cortex (V1). V1 is the primary visual cortex (also called the striate cortex) and it is located in the occipital lobe. Layer 4C-alpha receives input from the magnocellular cells and layer 4C-beta receives input from parvocellular cells. Layers 2-3 of V1 receive input from the koniocellular cells of the LGN. Processing in V1: Layer IVCa projects mainly to cells in layer IVB. Layer IVCb, projects mainly to layer II/III. In layers II/III and IVB, an axon may form synapses with dendrites of pyramidal cells of all layers. This represents parallel processing, and much spatial, temporal and chromatic information about the visual world is processed separately and in parallel in V1.

*24.What does it mean to say that V1 is retinotopic? What are ocular dominance columns in V1 (you may need to look this up)?*

Retinotopy of a visual area refers to that visual area sharing/preserving the topography of the retinal map. The map of the visual field projected onto the retina is maintained in higher areas of visual processing. Both the LGN and visual cortex maintain retinotopic mapping, include V1 and, to a lesser extent, most other areas responsible for visual processing (V2-6, MT).

Ocular dominance columns are alternating sections of V1 that receive input from either the ipsilateral eye or contralateral eye (hence “dominated” by that eye). Since both ipsilateral and contralateral input will manifest in the LGN (due to crossing at optic chiasm), the LGN and the V1 of both hemispheres will contain input from both eyes. Thus, these stripes/ columns in V1 will correspond to input from a single eye. The right LGN and right V1 receive information from left visual field (from both eyes) and the left LGN and left V1 receive information from the right visual field (from both eyes). Ocular dominance columns are considered a type of cortical column.

*25.Describe the features of “simple” and “complex” receptive fields in V1 neurons.*

Aligned LGN fields result in a simple cell field while an aligned simple cell fields create complex fields. Additionally, V1 simple neurons synapse and communicate with V1 complex neurons. Simple cell fields have excitatory and inhibitory regions as well. Complex cell fields only have oriented receptive fields and excitatory regions.

Simple receptive fields in V1 neurons respond to a specific orientation, but have antagonistic effects from stimulation of surround. Complex receptive fields in V1 neurons respond to specific orientation, but do not have antagonistic effects from surround.

*26.What is meant by “parallel processing” in the visual system? Give an example. Where does information first get integrated/combined in the visual system?*

Different submodalities of vision including color, motion, orientation, and contrast are processed simultaneously and then integrated together within the higher visual processing areas. For instance a red moving ball would have information about red color, shape, and movement, all of which would be processed in different cellular (parallel) pathways simultaneously. Some information first gets integrated/combined in V1 by the layer II/III cells.

*27.Describe the two basic anatomical streams (and their locations) that visual information follows out of V1, and what type of visual information they handle.*

The dorsal and ventral pathways are the two basic streams of visual information. The dorsal pathway is used for spatial understanding and movement within space. The dorsal stream (DS) appears to serve the analysis of visual motion and the visual control of action (it sends information directly to the motor cortex). The DS projects toward the parietal lobe. It is also called the “where” (and sometimes the “how”) pathway.

The ventral pathway deals mostly with object recognition and discriminating object features.

The ventral stream (VS) is thought to be involved in the perception of the visual world and the recognition of objects. The VS projects toward the temporal lobe. It is also called the “what” pathway.

The dorsal pathway/stream travels: V1-->V2-->MT-->Posterior Parietal

The ventral pathway/stream travels: V1-->V2-->V4-->Inferior Temporal

The dorsal stream is likely an extension of the V1 magnocellular pathway and the ventral stream is an extension of V1 parvocellular pathway.

*28.What is the fusiform face area?*

From Wikipedia: The fusiform face area is a part of the human visual system that is specialized for facial recognition. It is located in the Inferior temporal cortex (IT), in the fusiform gyrus (Brodmann area 37). The FFA is located in the ventral stream on the ventral surface of the temporal lobe on the lateral side of the fusiform gyrus. It is lateral to the parahippocampal place area. It displays some lateralization, usually being larger in the right hemisphere.

The FFA was discovered and continues to be investigated in humans using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) studies. Usually, a participant views images of faces, objects, places, bodies, scrambled faces, scrambled objects, scrambled places, and scrambled bodies. This is called a functional localizer. Comparing the neural response between faces and scrambled faces will reveal areas that are face-responsive, while comparing cortical activation between faces and objects will reveal areas that are face-selective. While it is generally agreed that the FFA responds more to faces than to most other categories, there is debate about whether the FFA is uniquely dedicated to face processing, or whether it participates in the processing of other objects. The expertise hypothesis suggests that the FFA is a critical part of a network that is important for individuating objects that are visually similar because they share a common configuration of parts.