Lecture 7 Review

As I mentioned on previously, these reviews are intended to help you focus your study time. They are not meant in any way to be a comprehensive summary of everything you will be expected to know for the exam. If I discussed a topic in lecture and fail to mention it in these reviews, you should not take this as an indication that this material will not be on the exam. You should read the book and study your notes.

The visual system is probably the most important sensory system in humans. We rely on this system more than any other in our daily lives. The visual system relies on the conversion of light energy into neural activity by photoreceptors located in the retinas of the eyes. The **retina** is a complex sensory organ consisting of multiple layers of cells. I reviewed the organization of the layers of the retina and you should know the names of each of the six layers and what each layer contains in terms of cell and synaptic connections.

There are two general types of photoreceptors in the retina of mammals, the **rods** and **cones**. In lecture, I discussed the similarities and differences in the morphology and function of these two receptor types. You should be prepared to compare and contrast these receptors on the exam. There is one type of rod, which contains the photopigment **rhodopsin**. Rhodopsin consists of an opsin protein that is conjugated with a photosensitive molecule called retinal, which is derived from vitamin A. Rhodopsin has a wide range of sensitivity to light wavelengths (400-650nm). This wide range of sensitivity and abundance of rhodopsin in rods allow rods to be active under low light (**scotopic** conditions). Cones are less sensitive to light energy and they have a narrower range of wavelengths to which they are sensitive. There are three types of cones, **red cones** (500-610nm), **green cones** (450-575), and **blue cones** (350-500nm). The cones are responsible for color vision. According to the **Helmholtz trichromacy theory**, the brain interprets the relative inputs from the three types of cones in perceiving the color of an object. Thus, just as in gustation and olfaction, the conscious sensation of a stimulus depends on population coding.

The rods and cones carry out the process of **phototransduction**, by which light energy is converted into electrical signal. Phototransduction occurs by basically the same process in both rods and cones. In lecture I described the process of phototransduction and you should be prepared to explain this process in detail for the exam.

In the processing of the light stimulus in the retina, the electrical signal transduced by the photoreceptors is passed from the receptors to the **bipolar cells** and subsequently to the **ganglion cells**. In most of the retina there is a convergence of inputs such that multiple receptors synapse onto a single bipolar cell, and multiple bipolar cells synapse onto a single ganglion cell. However, in the **fovea** there is a 1:1:1 relationship between receptors (which are all cones in this part of the retina), bipolar cells, and ganglion cells. In addition, the cell bodies of the bipolar cells and ganglion cells are displaced to the sides of the fovea, which allows light to have direct access to the cone receptors. As a result the fovea has a very high visual acuity. When you focus your visual attention on an object (i.e. you focus your eyes on it), you are positioning the image of the object so that if falls on the fovea.

The inputs from the photoreceptors onto the bipolar cells are organized into what are called **antagonist center-surround receptive fields**. You should understand the

anatomical basis of these receptive fields and how the bipolar cell responds to stimulation of each part of the receptive field. The antagonist center surround receptive field organization of the bipolar cells is passed onto the ganglion cells which pass this arrangement of receptive field sensitivity on to the cells in the lateral geniculate nucleus. The significance of this type of receptive field arrangement is that it emphasizes contrast in the visual field. The emphasis on contrast allows the visual system to distinguish individual objects and the borders between objects (i.e. the details of the visual field).

As well as being divided on the basis of whether they are on-center, off-surround or off-center, on-surround, ganglion cells can also be divided into two major groups based on their appearance, size of their receptive field, and type of stimulus to which they are most sensitive. On the basis of these criteria there are two types of ganglion cells, **P-cells** and **M-cells**. You should be prepared to describe these two types of ganglion cells. A third group of less well characterized ganglion called non-M non-P ganglion cells have also been identified. These cells have properties similar to both the M and P cells.

The ganglion cells are the output cells of the eyes, that is, they give rise to axons that carry the visual signal from the eye into the brain. The ganglion cell axons exit the back of the eye together to form the **optic nerve**. The optic nerve from each eye come together just anterior to the pituitary gland to from the **optic chiasm**. In the optic chiasm, the axons from the ganglion cells of the nasal retina of each eye decussate and enter the brain with the axons from ganglion cells of the temporal retina of the opposite eye. You should be prepared to explain the significance of the decussation of the axons in the optic chiasm. After the optic chiasm the ganglion cell axons constitute the **optic tract.**

The optic tract has four targets in the brain. You will be expected to know these four targets and how each of these targets uses the visual inputs it receives. The main target of the optic tract is the **lateral geniculate nucleus of the thalamus**. The neurons of the lateral geniculate nucleus are arranged in six layers that are numbered 1-6 from ventral to dorsal. The inputs from the optic tract are organized such that each layer gets monocular input as well input from either the P-cells or M-cells of the retina. According to this scheme, layers 1, 4, and 6 receive input from the contraleteral eye, and layers 2, 3, and 5 receive input from the ipsilateral eye. Layers 1 and 2 receive M-cell inputs, and layers 3-6 receive P-cell inputs. In addition to the six layers, there are also neurons that lie in between each layer. These neurons constitute the koniocellular layers. Inputs to the koniocellular layers come from an ill-defined type of ganglion cell called non-M non-P ganglion cells, that do not fit into either the P-cell or M-cell type.

The cells in the lateral geniculate nucleus relay their visual inputs to the **primary visual cortex (Brodmann area 17)**. This part of the cortex is also called **striate cortex**. The striate cortex has six layers like other parts of the isocortex. The layers of the striate cortex are numbered 1-6 starting with the most superficial layer. The book describes the synaptic organization in these layers, but for the exam you will not be expected to know this information in detail. However, you should know that the lateral geniculate inputs synapse in **layers IVC**α and β and that there are **three parallel pathways (channels) of visual information processing** in this part of the cortex. These channels are 1) **Magnocellular-pathway**, which is specialized for analysis of movement in the visual field and the guidance of motor actions. 2) **Parvocellular-IB pathway**, which is specialized for analysis of the shape of objects. 3) **Blob pathway**, which is specialized for analysis of object color.

The neurons in the striate cortex make synaptic contacts with many other areas of the cortex. The role of these areas in processing and integrating visual information is not clearly understood. In a very general sense there are two streams of visual processing beyond area 17. One stream is called the **dorsal or parietal lobe stream**. This stream appears to be devoted to the analysis of visual motion (the direction of movement of objects in the visual field). The other stream is called the **ventral or temporal lobe stream**. The ventral stream appears to be devoted to recognition of objects (ex. a pencil, or your grandmother's face, etc.).