10.8.5: Processing_Visual_Information

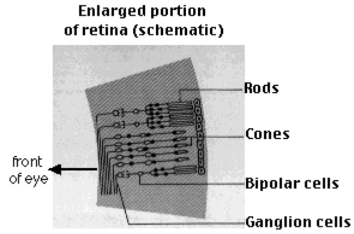

Figure 15.9.4.2 Ganglion cells

By inserting an electrode in a single ganglion cell, it was shown (by Stephen W. Kuffler) that

- Even in the dark, ganglion cells have a slow, steady rate of firing.
- Diffuse light directed on the retina has little effect on this rate.
- But a tiny **spot** of light falling on a small circular area of the retina can greatly increase the firing rate of some ganglion cells (left) while
- a spot directed around the perimeter of such an "**on**" area suppresses that ganglion cell (center).
- Light shining on both areas produces no effect (right).
- Other ganglion cells have a central "**off**" area surrounded by an "**on**" area.

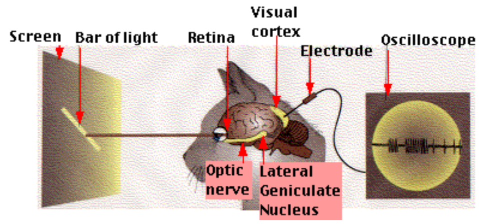

Figure 15.9.4.3 Lateral geniculate nucleus

Two associates of Kuffler, David H. Hubel and Torsten N. Wiesel inserted electrodes in these areas but instead of directing light into the eye, they projected images on a screen in front of the animal (an anesthetized cat or monkey). Using this procedure, they found that

- cells of the **lateral geniculate nucleus** (**LGN**) respond about the same way that ganglion cells do; that is, to **circular** spots of light.
- But the cells in the **visual cortex** receiving input from the LGN no longer respond to circles of light but only to **bars** of light (or dark) or to straight-line edges between dark and light areas.
- One of these "simple cortical cells" will only respond when the stimulus is directed at a particular area of the screen and at a specific angle. However, an ineffective position for one of these cortical cells is an effective position for another.

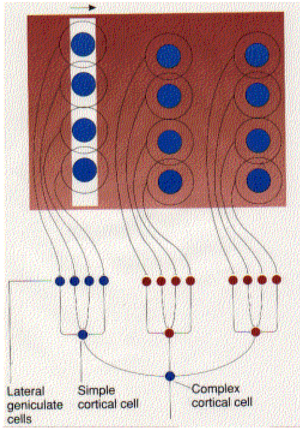

Figure 15.9.4.4 LGN

The diagram shows this mechanism by which the **circular response** areas of ganglion and **LGN** cells can be converted into the **rectangular response** areas found in the cells of the **visual cortex**. Other cells ("complex cortical cells") still want their edges oriented in one direction, but the edges can now be moved across the screen. As the figure shows, this can be explained if a set of simple cortical cells all responding to an edge of the same slope but each responsible for a different part of the visual field converge on a single "complex cortical cell". Thus these complex cortical cells continue to respond to the stimulus even though its absolute position on the retina changes.

While these studies provide only the tiniest glimpse into the workings of the brain, they provide some clues of what will be found:

- At each step of processing, the inputs of a number of interneurons are funneled into a single output.
- So, at each step, some of the information is selectively destroyed.
- A simple cortical cell, for example, fires only if a number of LGN cells converging on it are simultaneously active. Otherwise, the excitation dies out at the synapses.
- In this way, each level of the brain acts as a filtering device and, in doing so, provides a mechanism by which certain features of what might be a very complex stimulus can be discriminated..
- So instead of responding to particular impulses in particular circuits, the mammalian brain seems to respond to the spatial and temporal organization of many impulses passing along many converging circuits.

The importance of these studies was recognized by the award of a Nobel Prize in 1981 to Hubel and Wiesel (too late for Kuffler, who died in 1980).
