Visual Differences in the Brain

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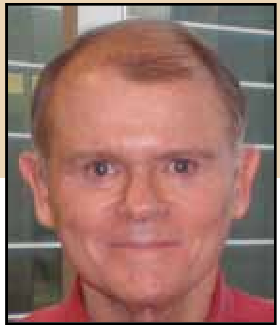


About two inches behind the bridge of the nose, optic nerve fibers from each eye meet at an X-shaped structure. The letter X is called "Chi" in the Greek alphabet; thus, this point of intersection is known as the optic chiasm – the optic crossing point. It is at the chiasm where the information from the two eyes is combined. In most people, about 45% of the fibers from each eye stay on the same side of the brain and 55% cross to the opposite side of the brain. However, in people with albinism, 80% or more of the optic fibers from each eye cross to the opposite side of the brain, with less than 20% remaining on the same side. On page 41 the schematic top view compares the right eyes of a person with eye pigment versus a person with albinism with little pigment. These percentages are estimates and likely vary considerably between individuals. In many animals exhibiting albinism, the proportion of optic nerve fibers that cross to the opposite side of the brain at the optic chiasm can be up to 99%.

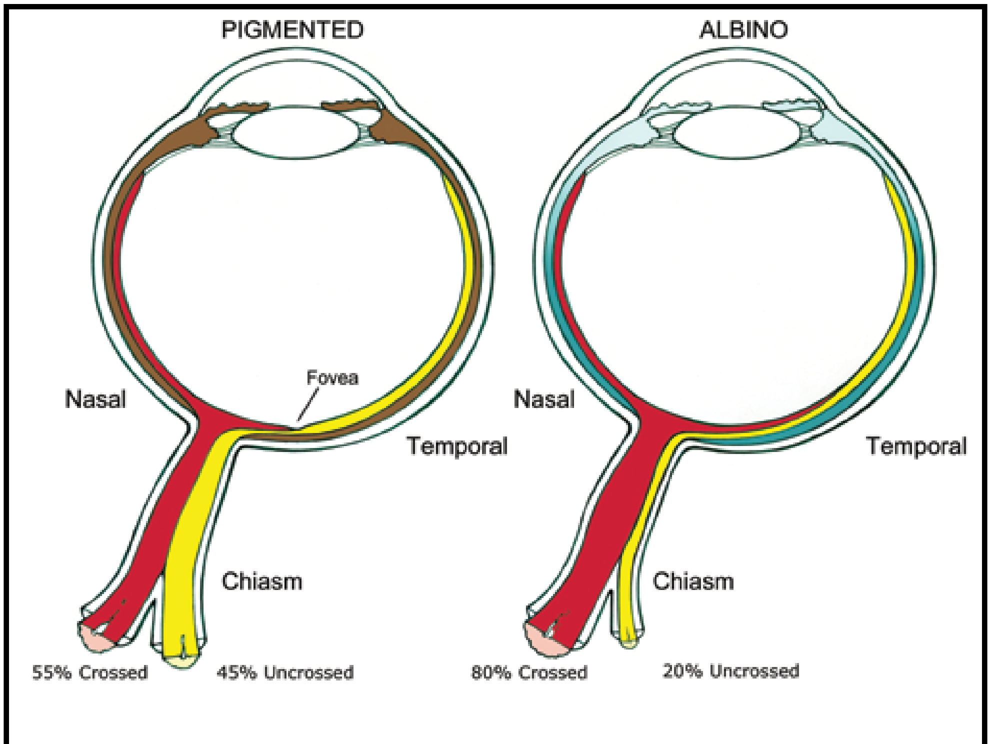
Humans have about one million optic nerve fibers in an optic nerve the size of a pencil. Each of these fibers is a single elongated cell called a retinal ganglion cell (RGC), most extending from the retina to the middle of our brains where they interact with similar cells from the other eye. The area of interaction is called the lateral geniculate nucleus (LGN). A few RGCs go to other centers controlling eye movement and coordinating visual and hearing information.

When the proportion of optic nerve fibers from each eye is near 50/50 the LGN is an orderly organization of layers alternating from each eye, right / left / right / left, one on top of the other like floors of a small building. Within this structure of alternating layers from each eye, are columns like a bank of elevators running up and down through the alternating layers. The organization is very orderly and is the basis for our brain's ability to sort out where information originates in visual space. Each point in our visual space is coded in an orderly manner in the columns and layers of our LGNs mapping our visual world.

In people with albinism, too many optic nerve fibers cross to the opposite side of the brain. When these fibers reach the LGN, there are too many fibers crowding into the layers for that eye. With not enough space in the appropriate layers, these fibers intrude into layers from the other eye fragmenting the layer-by-layer, and column-by-column organization. The consequence is the destruction of the orderly map of visual information, including the anatomical basis for binocular stereovision vision. Binocular "stereovision" vision is primarily coded at the visual cortex.

The eyes of most adults are over two inches apart. Each eye has a view from a slightly different angle. Good binocular vision is the result of separate images from the two eyes combined into one three-dimensional (3-D) image in the brain. Due to the fragmentation of the orderly arrangement of layers in the LGN, the anatomical basis for good stereovision is disturbed at the visual cortex.

Fortunately this destruction at the LGN level of the primary visual pathway, where less than half the visual cells respond normally, is corrected considerably at the cortical level. Other parts of the brain contribute to binocular vision. The brainstem visual centers that control eye movement also contain maps of visual space. Maps of visual space are present in the visual association cortices adjacent to primary visual cortex, and visual information from these other parts of the brain is communicated to the other side of the brain via a bundle of nerve fibers called the corpus callosum. The corpus callosum is an arched bundle of nerve fibers that connects the two cerebral hemispheres, facilitating communication between the right and left sides of the brain. With this added communication between hemispheres of the brain and multiple maps of visual space, the competence of the visual system improves greatly at the cortical level resulting in near-normal visual perceptual abilities – within the limits of that person's acuity.



Schematic drawing of approximate distribution of optic nerve fibers at the optic chiasm in pigmented people and people with albinism indicates largely preserved corticocortical connections.

What facilitates perceptual improvement of a person with albinism at the cortical level? For one, we have the multiple visual field maps on the surface of the brain. These visual maps cover the occipital lobe at the back of the head, and parts of both the parietal (side) and temporal lobes near the front of the brain. Information from these additional visual cortical areas complements visual perception. Additionally, information is exchanged between the cortical areas. Further visual information is contributed by centers deep in the brain that coordinate eye movement. Thus the perceptual deficiencies at the LGN are complemented, and thus nearly corrected, by the additional information from the several cortical and deeper brain areas.

A note regarding stereovision and visual acuity versus visual perception: Most people with albinism have poor 3-D stereovision and visual acuity due to a poorly formed fixation point in the eye called the fovea, as well as disruption of the visual map in the brain. Stereovision and visual acuity are not the same as visual perception. Visual perception is the end result of how we interpret the visual world, which combines the information from a number of visual areas of the brain plus our lifetime of learning about the world. Nevertheless, even with the improvement added by visual perception, people with albinism usually have poor visual acuity and poor stereovision.

For more information, visit **webvision.med.utah.edu**, and go to Part XI to read the chapter on albinism. Additionally, *Scientific American* published an excellent paper with good figures: R.W. Guillery, *Visual Pathways in Albinos*, 1974, May, pp. 44-54.