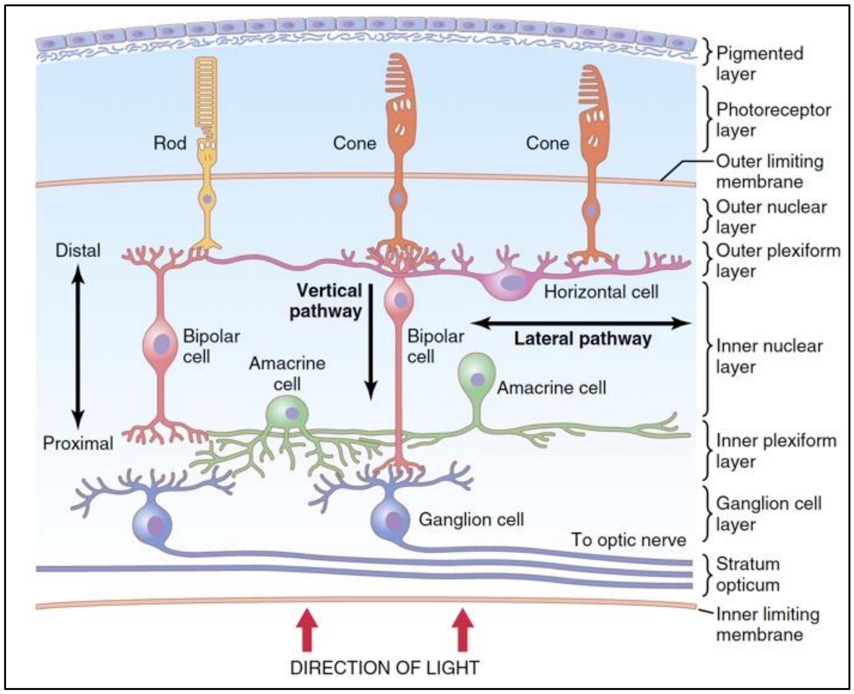
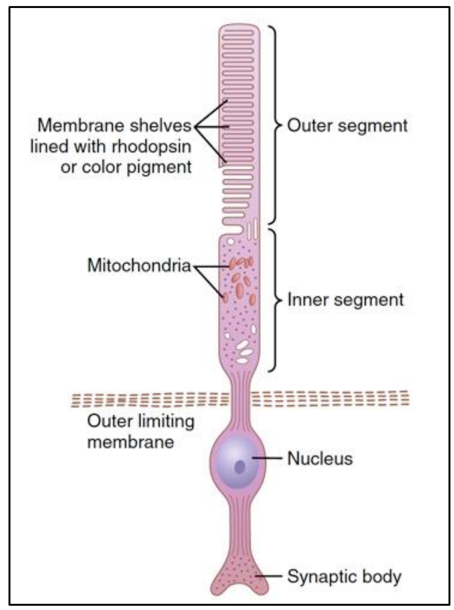
Vision-II



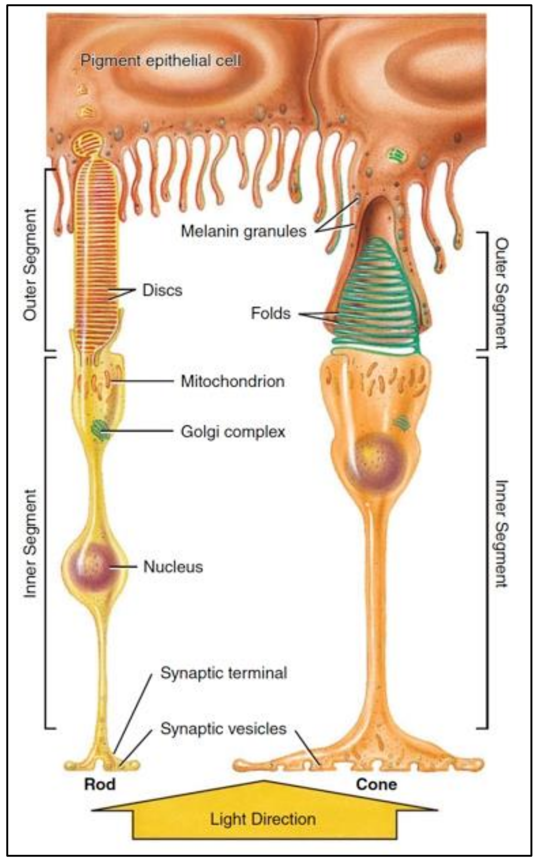
- The pigment layer also stores large quantities of vitamin A.
- This vitamin A is exchanged back and forth through the cell membranes of the outer segments of the rods and cones, which are embedded in the pigment.
- vitamin A is an important precursor of the photosensitive chemicals of the rods and cones.



- The major functional segments of either a rod or cone are:

  (1) the outer segment; (2) the inner segment; (3) the nucleus; and (4) the synaptic body.
- The light-sensitive photochemical is found in the outer segment. In the case of the rods, this photochemical is rhodopsin; in the cones, it is one of three “color” photochemicals, usually called simply color pigments, that function almost exactly the same as rhodopsin except for differences in spectral sensitivity.
- In the outer segments of the rods and cones, note the large numbers of discs. Each disc is actually an infolded shelf of cell membrane. There are as many as 1000 discs in each rod or cone.
- Both rhodopsin and the color pigments are conjugated proteins. They are incorporated into the membranes of the discs in the form of transmembrane proteins.
- The concentrations of these photosensitive pigments in the discs are so great that the pigments themselves constitute about 40% of the entire mass of the outer segment.
- The inner segment of the rod or cone contains the usual cytoplasm, with cytoplasmic organelles. Especially important are the mitochondria, which play the important role of providing energy for function of the photoreceptors.

- The synaptic body is the portion of the rod or cone that connects with subsequent neuronal cells, the horizontal and bipolar cells, which represent the next stages in the vision chain.



Rods vs cones:

shape, location, number, sensitivity to light, visual acuity, color, vision

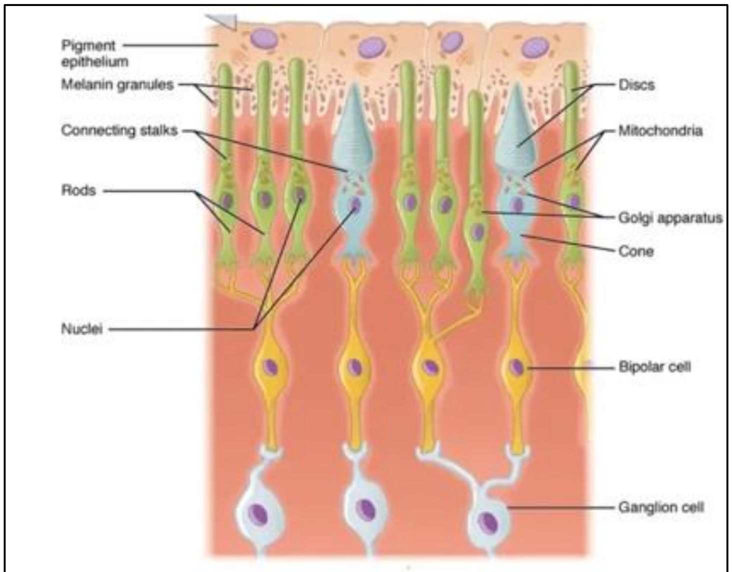
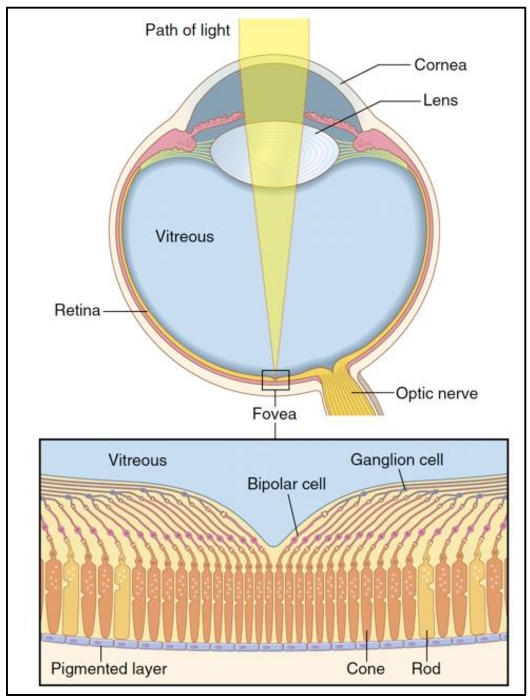
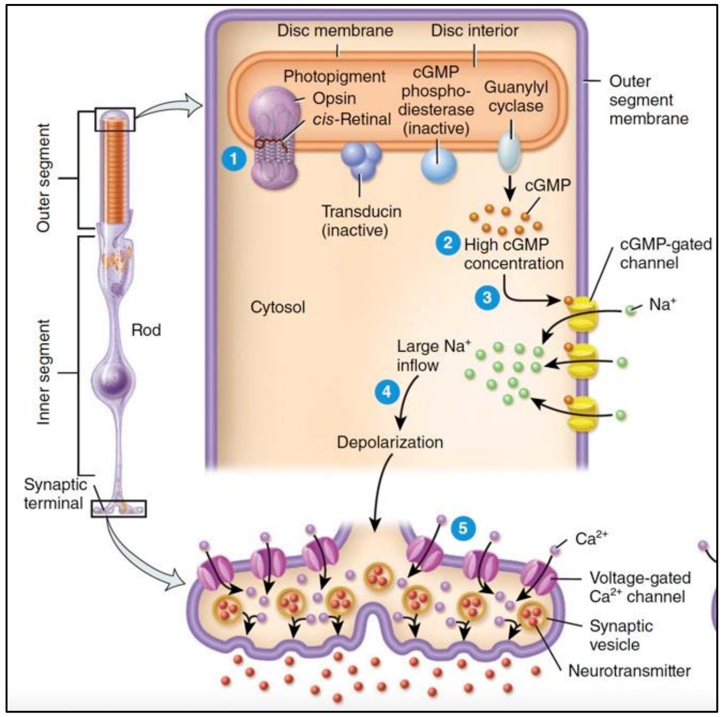


image source: wikipedia



- The fovea is a minute area in the center of the retina, especially capable of acute and detailed vision.
- The central fovea is composed almost entirely of cones. These cones have a special structure that aids their detection of detail in the visual image—that is, the foveal cones have especially long and slender bodies, in contradistinction to the much fatter cones located more peripherally in the retina.
- Also, in the foveal region, the blood vessels, ganglion cells, inner nuclear layer of cells, and plexiform layers are all displaced to one side rather than resting directly on top of the cones, which allows light to pass unimpeded to the cones.

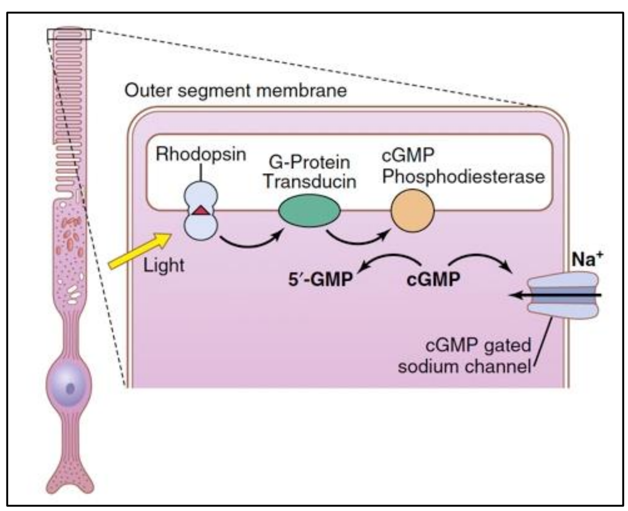
Rhodopsin and Its Decomposition by Light Energy.



- The outer segment of the rod that projects into the pigment layer of the retina has a concentration of about 40% of the light-sensitive pigment called rhodopsin, or visual purple.
- This substance is a combination of the protein scotopsin and the carotenoid pigment retinal.
- Furthermore, the retinal is a particular type called 11-cis retinal. This cis form of retinal is important because only this form can bind with scotopsin to synthesize rhodopsin.
- When light energy is absorbed by rhodopsin, the rhodopsin begins to decompose within a very small fraction of a second.

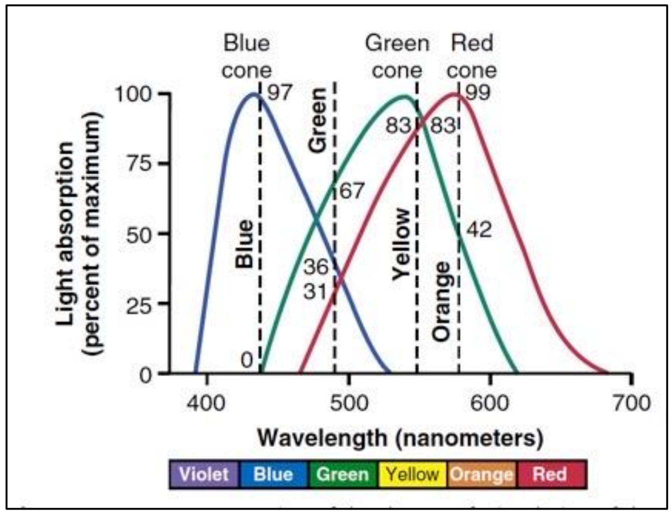
- all-trans retinal no longer fits with the orientation of the reactive sites on the protein scotopsin, the all-trans retinal begins to pull away from the scotopsin.
- Several changes lead to the formation of metarhodopsin II, also called activated rhodopsin, that excites electrical changes in the rods.

Re-Formation of Rhodopsin.



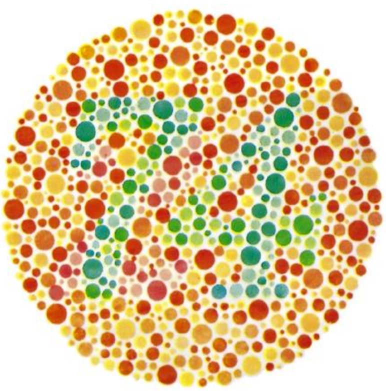
- The first stage in re-formation of rhodopsin is to reconvert the all-trans retinal into 11-cis retinal.
- This process requires metabolic energy and is catalyzed by the enzyme retinal isomerase.
- Once the 11-cis retinal is formed, it automatically recombines with the scotopsin to re-form rhodopsin, which then remains stable until its decomposition is again triggered by absorption of light energy.

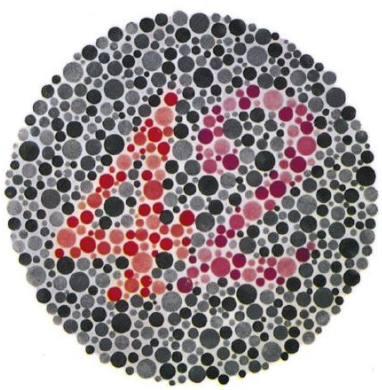
- There is a second chemical route whereby all-trans retinal can be converted into 11-cis retinal.
- This second route is by conversion of the all-trans retinal first into all-trans retinol, which is one form of vitamin A.
- Then, the all-trans retinol is converted into 11-cis retinol under the influence of the enzyme isomerase.
- Finally, the 11-cis retinol is converted into 11-cis retinal, which combines with scotopsin to form new rhodopsin.



Color vision

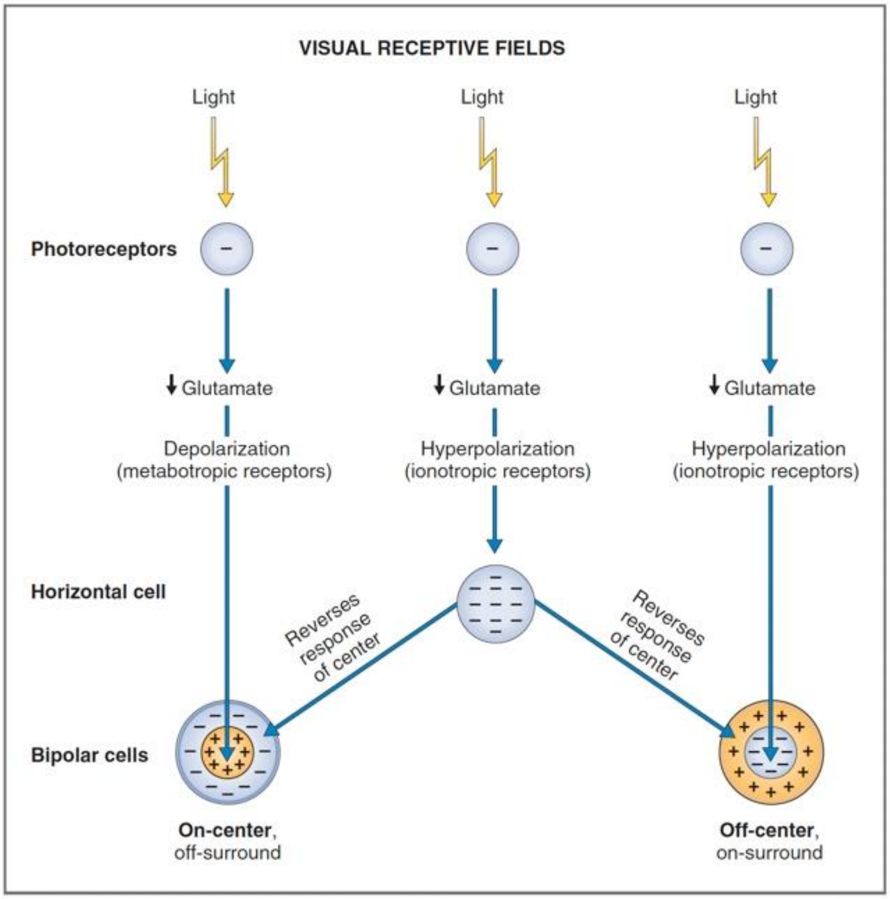
the ratios of stimulation of the three types of cones.
About equal stimulation of all the red, green, and blue cones gives one the sensation of seeing white.





Photoreceptor	Sensitivity to Light	Acuity	Dark Adaptation	Color Vision
Rods	Low threshold Sensitive to low-intensity light Night vision	Low acuity Not present on fovea	Adapt late	No
Cones	High threshold Sensitive to high-intensity light Day vision	High acuity Present on fovea	Adapt early	Yes

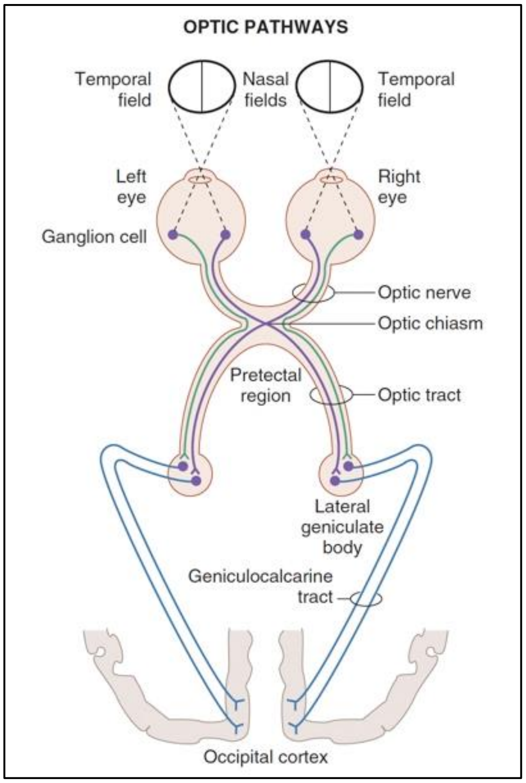
Dark and light adaptation

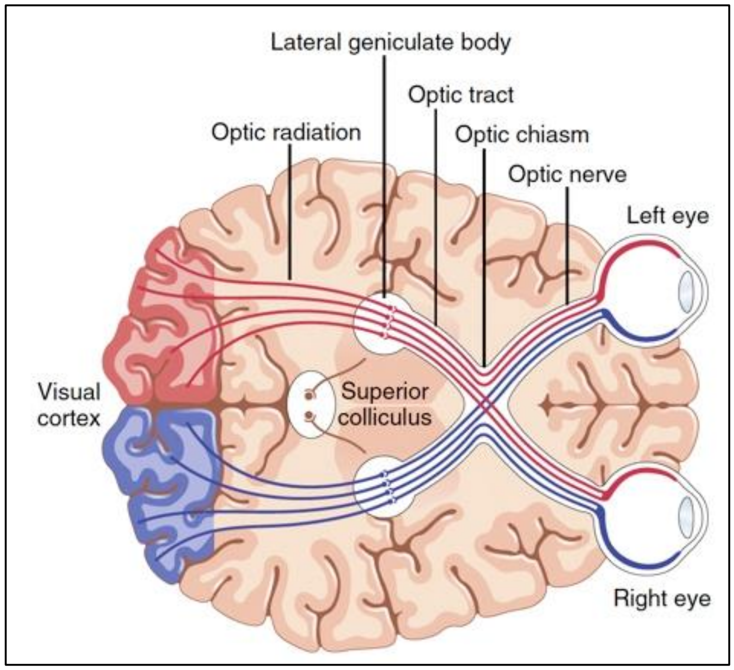


Retinal Ganglion cells

- Two general classes of retinal ganglion cells that have been studied most, are designated as magnocellular (M) and parvocellular (P) cells.
- The P cells (also known as beta cells or, in the central retina, as midget ganglion cells) project to the parvocellular (small cells) layer of the lateral geniculate nucleus of the thalamus.
- The M cells (also called alpha or parasol cells) project to the magnocellular (large cells) layer of the lateral geniculate nucleus, which, in turn, relays information from the optic tract to the visual cortex
- The main functions of M and P cells are obvious from their differences:
- The **P cells** are highly sensitive to visual signals that relate to fine details and to different colors but are relatively insensitive to low-contrast signals, whereas
- the **M cells** are highly sensitive to low-contrast stimuli and to rapid movement visual signals.

- A third type of photosensitive retinal ganglion cell has been described that contains its own photopigment, melanopsin.
- Much less is known about this cell type, but these cells appear to send signals mainly to nonvisual areas of the brain, particularly the suprachiasmatic nucleus of the hypothalamus, the master circadian pacemaker.



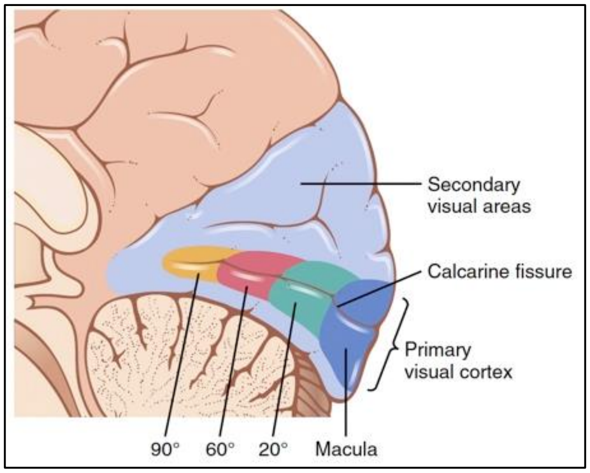


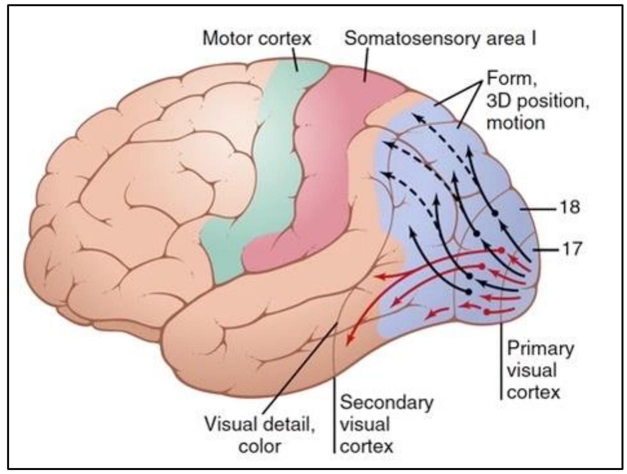
Dorsal lateral geniculate nucleus of the thalamus

- First, it relays visual information from the optic tract to the visual cortex by way of the optic radiation.
- This relay function is so accurate that there is exact point to point transmission with a high degree of spatial fidelity all the way from the retina to the visual cortex.
- The second major function of the dorsal lateral geniculate nucleus is to “gate” the transmission of signals to the visual cortex—that is, to control how much of the signal is allowed to pass to the cortex. The nucleus receives gating control signals from two major sources:

  (1) corticofugal fibers returning in a backward direction from the primary visual cortex to the lateral geniculate nucleus; and
  (2) reticular areas of the mesencephalon.

- Both of these sources are inhibitory and, when stimulated, can turn off transmission through selected portions of the dorsal lateral geniculate nucleus. Both of these gating circuits help highlight the visual information that is allowed to pass.





- This cortical area deciphers whether the respective areas of the two visual images from the two separate eyes are "in register" with each other—that is, whether corresponding points from the two retinas fit with each other.
- The information observed about degree of register of images from the two eyes also allows a person to distinguish the distance of objects by the mechanism of stereopsis.
- The visual signal in the primary visual cortex is concerned mainly with contrasts in the visual scene, rather than with noncontrasting areas.
- the intensity of stimulation of most neurons is proportional to the gradient of contrast—that is, the greater the sharpness of contrast and the greater the intensity difference between light and dark areas, the greater the degree of stimulation.
- Visual Cortex Also Detects Orientation of Lines and Borders—"Simple" Cells.
- "Complex" Cells Detect Line Orientation When a Line Is Displaced Laterally or Vertically in the Visual Field.
- Detection of Lines of Specific Lengths, Angles, or Other Shapes.