are concentrated toward the center of the field of vision at the back of the retina. There is a small pit called the fovea where almost all the light sensing cells are cones. This is the area where most "looking" occurs (the center of the visual field where detail, color sensitivity, and resolution are highest).

While the cones and their associated nerves are well suited to detecting fine detail and color in high light levels, the rods are better able to detect movement and provide vision in dim light. The rods are unable to discern color but are very sensitive at low light levels. The trouble with rods is that a large amount of light overwhelms them, and they take a long time to "reset" and adapt to the dark again. There are so many cones in the fovea that the very center of the visual field hardly has virtually no rods at all. So in low light, the middle of the visual field is not very sensitive, but farther from the fovea, the rods are more numerous and provide the major portion of night vision.

The area where the optic nerve enters the eyeball has no rods or cones, leaving a blind spot in the field of vision. Normally, each eye compensates for the other's blind spot. *Figure 16-13* provides a dramatic example of the eye's blind spot. Cover the right eye and hold this page at arm's length. Focus the left eye on the X on the right side of the windshield and notice what happens to the airplane while slowly bringing the page closer to the eye.

Empty-Field Myopia

Empty-field myopia is a condition that usually occurs when flying above the clouds or in a haze layer that provides nothing specific to focus on outside the aircraft. This causes the eyes to relax and seek a comfortable focal distance which may range from 10 to 30 feet. For the pilot, this means looking without seeing, which is dangerous. Searching out and focusing on distant light sources, no matter how dim, helps prevent the onset of empty-field myopia.

Night Vision

It is estimated that once fully adapted to darkness, the rods are 10,000 times more sensitive to light than the cones, making them the primary receptors for night vision. Since the cones are concentrated near the fovea, the rods are also responsible for much of the peripheral vision. The concentration of cones in the fovea can make a night blind spot in the center of the field of vision. To see an object clearly at night, the pilot must expose the rods to the image. This can be done by looking 5° to 10° off center of the object to be seen. This can be tried in a dim light in a darkened room. When looking directly at the light, it dims or disappears altogether. When looking slightly off center, it becomes clearer and brighter.

Refer to *Figure 16-14*. When looking directly at an object, the image is focused mainly on the fovea, where detail is best seen. At night, the ability to see an object in the center of the visual field is reduced as the cones lose much of their sensitivity and the rods become more sensitive. Looking off center can help compensate for this night blind spot. Along with the loss of sharpness (acuity) and color at night, depth perception and judgment of size may be lost.

While the cones adapt rapidly to changes in light intensities, the rods take much longer. Walking from bright sunlight into a dark movie theater is an example of this dark adaptation period experience. The rods can take approximately 30 minutes to fully adapt to darkness. A bright light, however, can completely destroy night adaptation, leaving night vision severely compromised while the adaptation process is repeated.

Figure 16-13. *The eye's blind spot.*

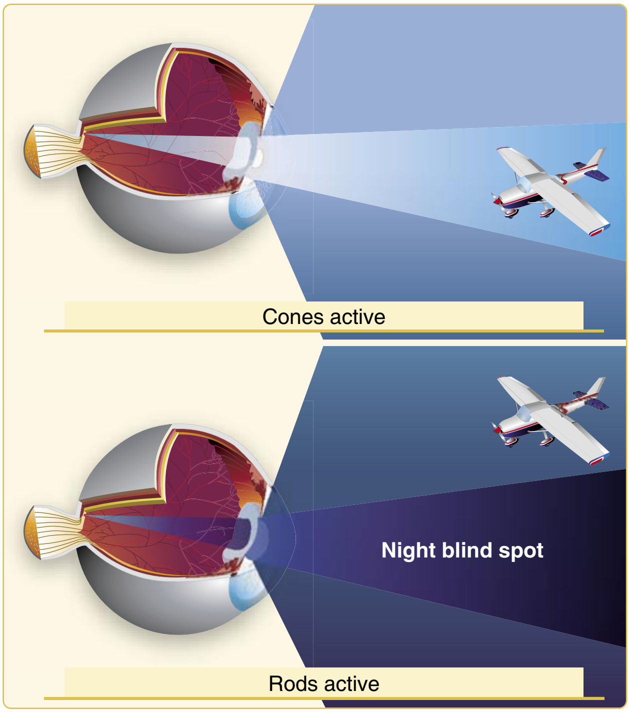

Figure 16-14. *Night blind spot.*

Hypoxia also affects vision. Sharp clear vision, (with the best being equal to 20-20 vision) requires significant oxygen especially at night. As altitude increases, the available oxygen decreases, degrading night vision. Compounding the problem is fatigue, which minimizes physiological well being. Adding fatigue to high altitude exposure is a recipe for disaster. In fact, if flying at night at an altitude of 12,000 feet, the pilot may actually see elements of his or her normal vision missing or not in focus. Missing visual elements resemble the missing pixels in a digital image while unfocused vision is dim and washed out.

For the pilot suffering the effects of hypoxic hypoxia, a simple descent to a lower altitude may not be sufficient to reestablish vision. For example, a climb from 8,000 feet to 12,000 feet for 30 minutes does not mean a descent to 8,000 feet will rectify the problem. Visual acuity may not be regained for over an hour. Thus, it is important to remember, altitude and fatigue have a profound effect on a pilot's ability to see.

Several things can be done to keep the eyes adapted to darkness. The first is obvious: avoid bright lights before and during flight. For 30 minutes before a night flight, avoid any bright light sources, such as headlights, landing lights, strobe lights, or flashlights. If a bright light is encountered, close one eye to keep it light sensitive. This allows the use of that eye to see again when the light is gone.

Red flight deck lighting also helps preserve night vision, but red light severely distorts some colors and completely washes out the color red. This makes reading an aeronautical chart difficult. A dim white light or a carefully directed flashlight can enhance night reading ability. While flying at night, keep the instrument panel and interior lights turned up no higher than necessary. This helps to see outside references more easily. If the eyes become blurry, blinking more frequently often helps.

Diet and general physical health have an impact on how well a pilot can see in the dark. Deficiencies in vitamins A and C have been shown to reduce night acuity. Other factors, such as CO poisoning, smoking, alcohol, certain drugs, and a lack of oxygen also can greatly decrease night vision.

Night Vision Illusions

There are many different types of visual illusions that commonly occur at night. Anticipating and staying aware of them is usually the best way to avoid them.

Autokinesis

Autokinesis is caused by staring at a single point of light against a dark background for more than a few seconds. After a few moments, the light appears to move on its own. To prevent this illusion, focus the eyes on objects at varying distances and avoid fixating on one target. Be sure to maintain a normal scan pattern.

False Horizon

A false horizon can occur when the natural horizon is obscured or not readily apparent. It can be generated by confusing bright stars and city lights. It can also occur while flying toward the shore of an ocean or a large lake. Because of the relative darkness of the water, the lights along the shoreline can be mistaken for stars in the sky. *[Figure 16-15]*

Night Landing Illusions

Landing illusions occur in many forms. Above featureless terrain at night, there is a natural tendency to fly a lower-than-normal approach. Elements that cause any type of visual obscurities, such as rain, haze, or a dark runway environment can also cause low approaches. Bright lights, steep surrounding terrain, and a wide runway can produce the illusion of being too low, with a tendency to fly a higher-than-normal approach. A set of regularly spaced lights along a road or highway can appear to be runway lights. Pilots have even mistaken the lights on moving trains as runway or approach lights. Bright runway or approach lighting systems can create the illusion that the airplane is closer to the runway, especially where few lights illuminate the surrounding terrain.

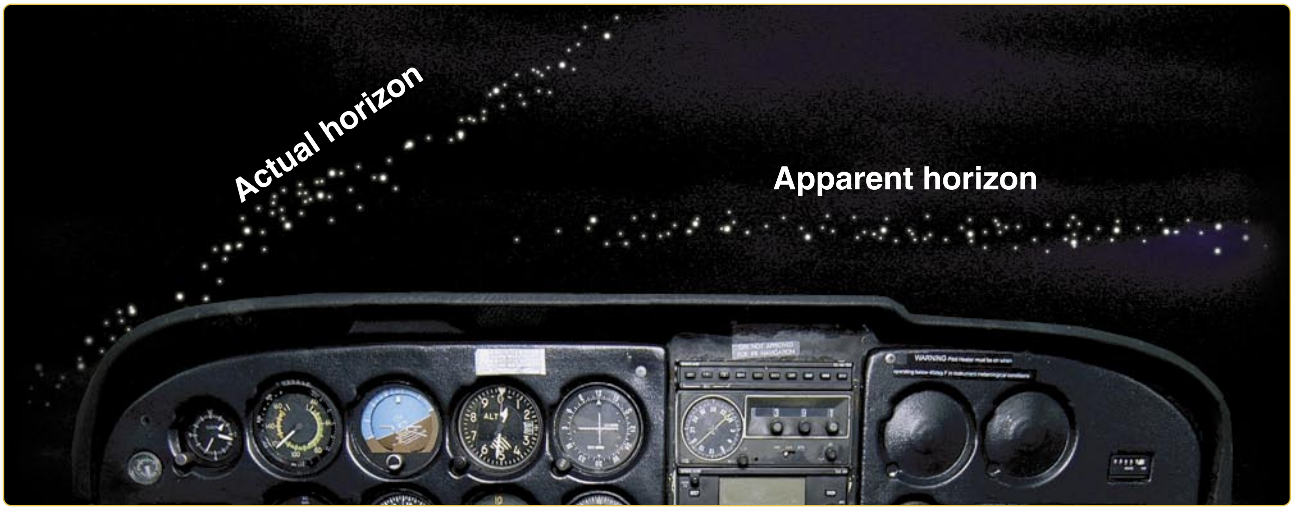

Figure 16-15. *At night, the horizon may be hard to discern due to dark terrain and misleading light patterns on the ground.*

Pilots who are flying at night should strongly consider oxygen supplementation at altitudes and times not required by the FAA, especially at night, when critical judgement and hand-eye coordination is necessary (e.g., IFR), or if a smoker or not perfectly healthy.

Chapter Summary

This chapter provides an introduction to aeromedical factors relating to flight activities. More detailed information on the subjects discussed in this chapter is available in the Aeronautical Information Manual (AIM) and online at www.faa.gov/pilots/safety/pilotsafetybrochures.