the normal lens, about 7.3 cm in front of the far point (*1*). Values of magnification for a distant object and one at 72 cm are given in Table 1.

It is clear that for a distant object the farther the lens is held from the eye, the greater the required focal length and the greater the magnification. For an object at 72 cm the required focal length at first increases and then decreases as the lens is held farther in front of the eye. Since magnification increases with lens distance, one might think the farther the better. However, in addition to the awkwardness of holding a lens far from the eye, there is also the disadvantage that the field of view decreases with lens distance. A more practical solution for many purposes is a lens with a focal length of about 16 cm (power, +6.25 diopters). With such a lens an aphakic eye can (i) focus far objects with a magnification of ×2; (ii) when moved farther out from the eye, focus near objects with a magnification of ×4; and (iii) when moved out still farther, focus near objects with a magnification of more than ×20. The range of distances that this lens can focus is infinity to 59 cm. What a remarkably useful optical instrument a simple lens becomes when combined with an aphakic eye! Of course, magnification is not always desired. To minimize it, a high-power lens must be close to the eye. This is one reason why contact lenses are often used to correct aphakia; they magnify only about 10 percent.

In practice a simple lens will produce aberrations which reduce image quality. Quality can be improved by using a lens system consisting of two or more elements designed to reduce aberration. Davenport gets excellent image quality by use of an achromatic projector lens system (50 millimeters in diameter) with a focal length of 15 cm. The metal tube which holds the lenses also serves to reduce stray light. These advantages are obtained at the cost of more bulk and a slightly higher price ($10 secondhand at a photography shop).

Why cannot the normal eye get the same advantage from a comparable system? Put simply, any lens that produces appreciable magnification also changes the vergence of the rays. This tends to put objects out of focus for the normal eye, but in focus for the aphakic eye. The normal eye needs at least two lenses to achieve the same result. The simplest system that does this is the Galilean telescope (Fig. 1b). This consists of a converging lens (objective) and a diverging lens (eyepiece) usually mounted in a variable length tube. The Galilean system has essentially the same optical properties as the converging lens–aphakic eye system. The reason for this similarity is that removing the lens of the eye is optically equivalent to adding a diverging lens. In effect, cataract surgery provides the aphakic person with a built-in eyepiece.

Finally there is the second fringe benefit of cataract surgery, the enhancement of color and brightness. The normal lens absorbs light of all wavelengths but particularly in the blue, and this absorption increases with age (*2*). When the lens is removed this light reaches the receptors, producing larger responses particularly in the short-wavelength cones. In addition ultraviolet light, normally almost completely absorbed by the lens, now reaches the retina (*3*). This has two effects. It is absorbed directly by the short-wavelength cones producing a violet sensation, and it causes the retina to fluoresce, producing visible light of a wide range of wavelengths up to 600 nanometers. This light appears greenish blue. One is reminded, however, that high-intensity ultraviolet may be damaging to the unshielded aphakic eye.

In summary, the aphakic eye both transmits more light than the normal eye and, aided by a simple converging lens, can produce sharp retinal images with a wide range of magnification. These properties add greatly to esthetic enjoyment, particularly for the flower lover (*4*), collector of small insects, jewel fancier, or "museum-watcher." Davenport may be one of the few persons in the world who, when he went to the Tutankhamon exhibit, *took out* his contact lens.

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References and Notes

1. Relative magnification is $d_i d'_o / d_o d'_i$, where d_i, d_o refer to the image distance for the correcting lens and d'_i, d'_o to these same distances for a lens 7.3 cm in front of the far point (that is, d'_o = 7.3 cm). When the object is very far away, $d_o \approx d'_o$ and relative magnification is d_i/d'_i.
2. Y. Le Grand, *Light, Color and Vision* (Chapman & Hall, London, 1968).
3. G. Wald, *Science* **101**, 653 (1945).
4. In a recent brief experiment, in which with his aphakic eye and contact lens Davenport observed through a filter with an upper cutoff at 360 nanometers a sunbathed flower of the Carolina jasmine *(Gelsemium sempervirens)*, he could clearly discern the pattern of the ultraviolet-reflecting ("honey-guide") tissue of the petals. "*One side*, bees!"

Erratum: A report described in the 27 April issue (News and Comment, p. 389) was incorrectly identified. It was coauthored by Rosemary Chalk and Frank von Hippel for the Committee on Scientific Freedom and Responsibility of the AAAS and will be published in a forthcoming issue of *Technology Review*.