

Inquiry D: Is anything going on in there?

Visualizing the optics of the eye.

It may be necessary to move the eye in order to “see it work,” but at this point it should be possible to aim the front of the eye toward a bright object outside. If the overhead lights in the room are dim an image should form on the white circular area of the retina. It may be necessary to cover the top of the model in order to improve the contrast of the image. The image will be quite small and somewhat dim, but should be visible as an inverted image (upside down and backwards). This provides a good opportunity to point out to students what happens when light rays enter the eye, i.e. refraction by the aqueous and vitreous humors, cornea, and lens and the effect the pupil diameter in the iris has on the brightness and clarity of the image. It’s a good idea to have students observe the effect that removing the paper shade and the iris lens have on the quality of the image. It is also notable to have students try each of the other lenses in the box in place of the +7 diopter lens, particularly the + 20 diopter lens. In this method, it is rather difficult to maintain a consistent and large enough image by utilizing a distant object, therefore the eye must be adapted for indoor use with the patterned image light source.

Without knowing it, perhaps, the students in your class are now ready to perform their first inquiry based “experiment.” Here’s a description of the question/problem they will have to solve.

- Assume that you now have the Cenco eye model set up and configured in the manner which represents a normal eye, as if it were focused on a distant object and it is still set up that way. (Students will have moved the “eye box model” near a window and aimed it at some brightly lit object at a distance outside.)
- If the eye model is returned to its place at your lab bench/table without changing the configuration used for distance vision, place the illuminated patterned image light box in front of the eye. How must it be configured in order to focus the highest quality image on the fovea centralis area of the retina? Consider all of your options including moving the light box closer or further or altering the internal components of the model eye itself in order to achieve better acuity of the image.

This problem employs the principle of near point accommodation and can be solved by considering the optical physics involved. If students understood the concept of near-point accommodation then they will have learned that at a closer distance objects must be focused on the retina with a smaller focal distance. In order to promote convergence of the light rays on the central fovea as needed to form the clearest possible image, several internal changes must occur in the eye. Assuming the patterned image light source box has been moved to a very short distance in front of the eye, students will quickly observe that no matter how close they get to the eye the only way to make the image clearer is not to move it closer but to move it even farther away. As they do this the image will decrease in size and brightness making it appear more clearly focused but dimmer and extremely small. Some groups may consider moving the retina. This won’t help much, and actually alters the eye from being

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This material is based on work supported by the National Science Foundation under Grant No. DUE 9987332.

normal to abnormal, which violates the condition set forth in the scenario. If the retina is moved forward it will only make the image worse since this represents the length of a hypermetropic (far-sighted eye). If the retina is moved to the farthest slot from the front of the eye it may improve the focus but only very slightly. At this length the eye is actually myopic (nearsighted). But it is actually impossible to focus the image on the retina under these conditions without near point accommodation by the lens. Remember that in the human eye this is achieved by altering the tension on suspensory ligaments which not only hold the lens in place, but also can dramatically change the shape of the lens through contraction or relaxation of the ciliary muscle fibers attached to the suspensory ligaments. If students were paying attention they should have noticed that the lens in the eye when viewing the distant object is not a very convex, but fairly flat and thin lens. From the previous discussion they should know this is best suited to viewing distant objects. The students proceeding on the right track to solving the problem should be looking for a lens change, typical of what would go on in a normal “accommodating” human eye. Examples of one that offers the most refraction in the shortest distance are a magnifying glass and one with a double convex shape. The one fitting the bill is the +20 diopter lens. Ideally students should discover that by replacing the +7 lens with the +20 lens and positioning the light box 33 cm from the front side of the cornea the sharpest image will be achieved. This configuration represents normal distance visual acuity with near-point accommodation. The effect the iris and pupil size have on this can be demonstrated by simply removing and replacing and observing the effect each of these has on the image.

Once again a means of progressive or non-formative assessment can be quickly used on a group-by-group basis. The teacher can rotate around the room and visit each group while checking their progress. If desired, a formal plan to solve the problem could be written by each group showing employment of the scientific method in attempting to systematically solve the problem or answer the question posed. With little additional work each group could be asked to design/plan an experiment which included each of the traditional elements applying the scientific method. A pre-printed worksheet or list of similar instructions to guide student discovery could also be posted on the chalkboard or overhead projector with the following or a similar sample format.

Please find at appendix C an outline of scientific method “stepwise” with sample student responses.