Perceptual Optics — 2. What Does a Lens Do?

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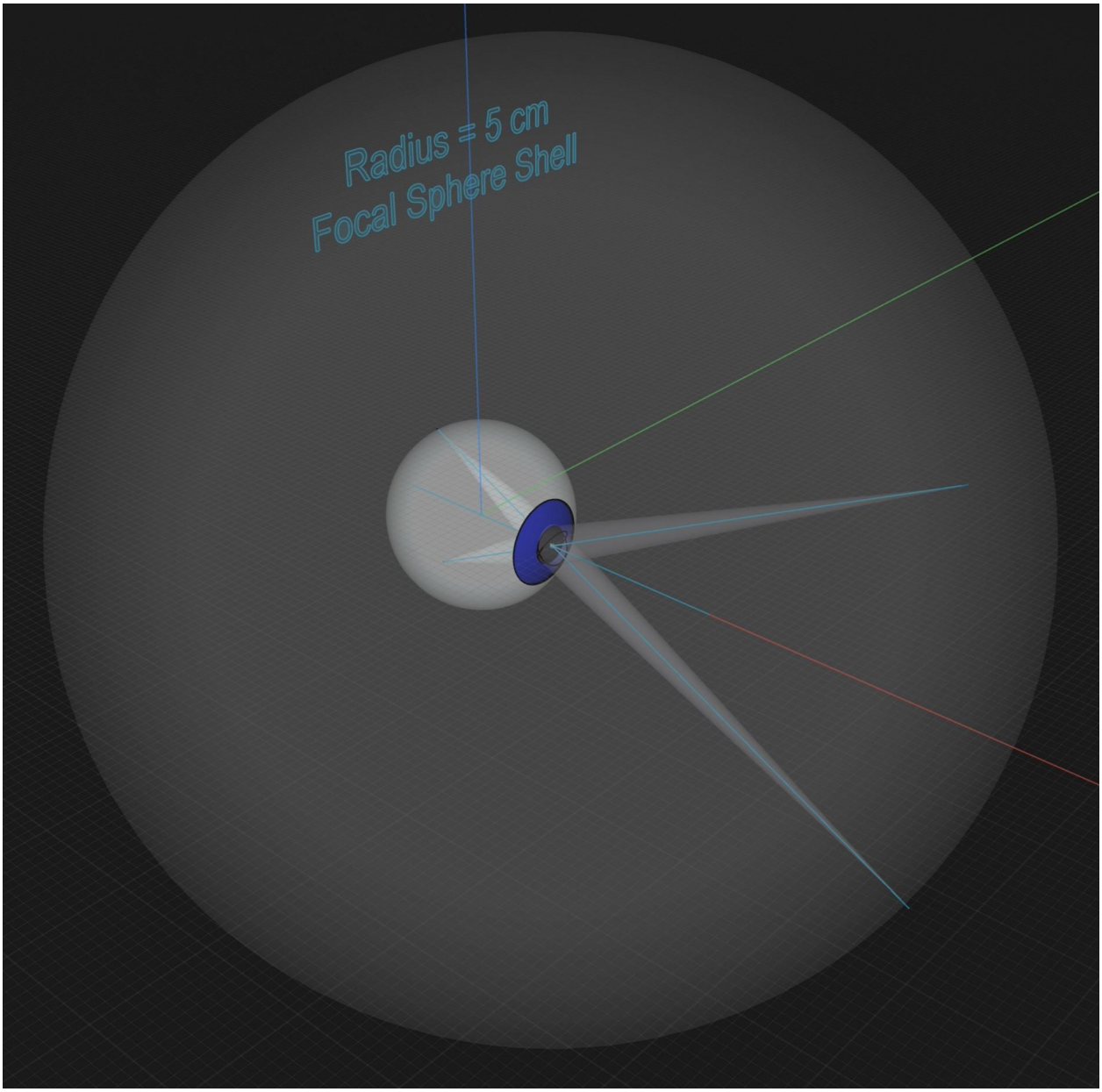
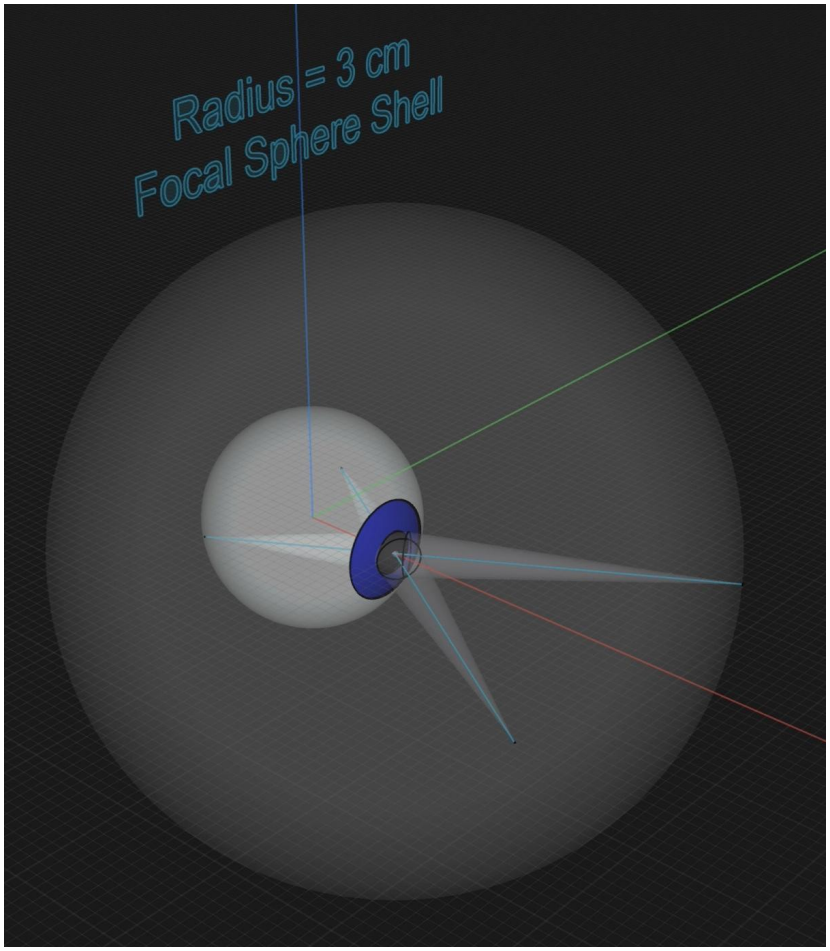
In lesson one, we saw that the pinhole camera was pretty good, but could improve in letting more light in and in increasing image clarity. To let more light in, we make the hole a good bit larger. In doing so, we must now add a **lens** to *bend* the now present *cone of light* from each point in the world back to a point upon reaching the sensor. In the eyeball below, each light ray is able to spread into a cone the width of the pupil upon reaching the pupil, and must be bent back to a point at just the right distance. *But this solution introduces another problem! Now we can only have a single "plane" in focus, because light rays from differing distances make different "solid angle" cones that need differing degrees of focusing power to correct them!*





The human eye uses the cornea to provide most of the focusing power, while allowing the lens to be variable in its degree of power, allowing us to focus on near or far things.

In reality, focusing on near things (as image at left) requires the most focusing power, and the human uses a triad — eye focus, vergence (turning eyes medially), and constriction of the pupil (to make it more like a pinhole!). It seems the eye is already well on its way to starting off with voxels rather than just pixels (understanding the depth of where the light came from), at least for the one in the foveal center-view (the most important one).

As a point of explanation, a lens is able to bend light based on the shape and the index of refraction. But remember that the whole point is, as in the image above, to bend a muddy cone of light back into a single point at a certain distance. In so doing, the lens also solves the other two problems of pinholes — too much “circle of confusion” from size of hole and too much “circle of confusion” from diffraction effects — the lens can, at least for a single focal “plane,” artificially create an extremely high level of resolution and clarity!

As a final point concerning lenses, consider that each point that is equidistant from the pupil or lens will create a cone of light that shares the same solid angle and therefore needs the same power of focus to resolve to a point on the sensor. What shape is equidistant from the center of the lens? A hemisphere shell! Surprisingly, there is no such thing as a flat “focal plane,” but rather a “focal sphere shell.” Of course, the back side of the sphere would be occluded, so it’s more like a hemisphere shell.

There’s no point trying to understand anything about cameras or eyes or visual perception until you have a firm grasp of the concepts in this and the pinhole paper, and until you realize why they are the fundamentals of optics. The contents of these two papers are rare, but true. You must spend the time here to appreciate these concepts because it will get “curiouser and curiouser” as we work up to visual perception and consciousness itself!