appeared on 22nd Dec 2004

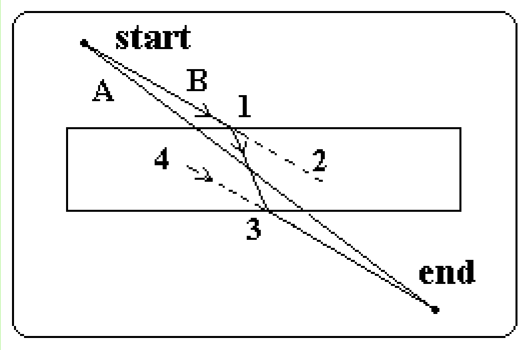
Scientists fish for better optics

Lenses that bend and focus rays of light quite effectively in everyday use would hardly work if they were used under water, says S.Ananthanarayanan.

The reason that glass lenses work when in air is that light moves slower through glass than through air. This causes light beams to bend when they cross from air to glass or vice versa. But the speed of light through water is almost the same as the speed through glass and glass lenses are much less powerful when used under water.

Shortest paths

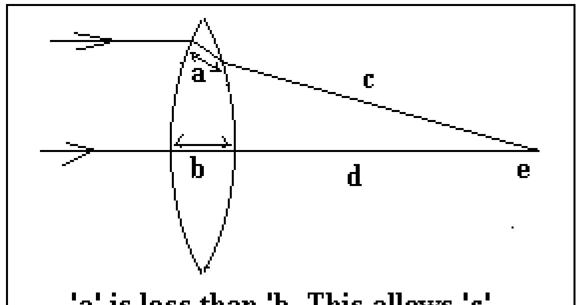
The path light follows from one point to another is the quickest path between the two points. If the path is all in the same medium, this is clearly the straight line between the two points. But if there is an intervening medium where light moves a little slower, then the straight line would not be the quickest path.



As we can see in the picture, the path ‘B’ is longer, but it is quicker, because there is less of the slow, glass portion to cover in this path.

The result is that at the point ‘1’ the ray of light seems to bend towards ‘3’. And ar ‘3’, the ray seems to come from ‘4’.

If the slab of glass were not straight but curved, like in a lens, then a beam would ‘converge’, because the parts of the beam striking the edges of the lens are turned in more than the parts nearer the center. The reason is also mainly because it takes longer to pass through the center than through the edges.



'a' is less than 'b. This allows 'c' to be more than 'd', for focus at 'e'

Lenses and eyes

This property helps make lenses that focus light within small distances, like in cameras, telescopes or even our own eyes. And the reason is mainly that light travels a lot faster in air than in glass or the material of the lens of the eye. But if the lenses were to be made to work in water, this difference in the speed of light would not be true any more. This is because the speed of light in water is nearly the same as that in glass. Light thus turns very little in going from water to glass or vice versa.

Glass lenses to be used under water would then need to be very bulky. Things like telescopes to work under water would then need to be much larger. This would also be true of the natural lenses in the eyes of animals, which depend a lot on their shape to focus light.

Underwater world

But eyes in nature, especially when they need high power under water, also use a nice workaround. What a lens needs for it to function is a gradually reducing optical path as one moves out from its center. The octopus, instead of using a lens that gets narrower as one moves to the edges, simply uses a gradually changing material! The octopus eye is found to consist hundreds of thousands of wafer-thin layers of differing optical density. This kind of lens can bend light more strongly at the edges without needing to be thicker in the middle. The lens is thus not bulky. Changing the focus, to switch from seeing a near object to a distant one is also possible with switch of layers, which may be more efficient than squeezing the lens to a different shape.

The lens of the human eye too, consists of about 22,000 layers, and the light bending quality of the material is not the same at all parts of the lens. But the octopus, which needs sharp eyesight under water, is able to focus light five times more strongly than human eyes. Scientists at the University of Washington, Seattle have mimicked the idea and created plastic films using 2 kinds of polymers. By varying the ratio of the polymers, the films can differ in light-bending strength by steps of 1%.

With very thin films like this one could build high power optical lenses that are light and flat instead of large and bulky!

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