Globular proteins found to allow squid eyes to adjust for light distortion

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(Phys.org)—A team of researchers with the University of Pennsylvania has uncovered the means by which squid eyes are able to adjust to underwater light distortion. In their paper published in the journal

Science, the group describes their work analyzing squid eye parts under a microscope, what they found and then offer an explanation of the process involved in squid vision. Tobias Madl with Medical University of Graz in Austria offers an overview of how lenses work in general in a Perspective piece in the same journal issue, and outlines the work done in this new effort.

Prior work with squid had shown that their eyes are unique. The refractive index of each lens is greatest at its center and grows smaller toward the edges. This contrasts sharply with how glass lenses work —they have the same refractive index over their whole area—their shape focuses the light. The unique squid lens has clearly evolved to better handle the murky light available in the ocean, allowing the creatures to see much better than humans and many other sea creatures that have traditional lenses. In this new effort, the researchers sought to learn how the squid eye is able to pull off this feat.

The study consisted of cutting squid eyes and studying them layer by layer under a microscope and applying small-angle X-ray scattering to learn more about the way light behaved as it encountered each layer and part of a lens. The researchers found that the lens was made mostly of a protein gel in the S-crystalline family. They attribute changes in the refractive index to the arrangement of the crystalline molecules. They found that in the center of the lens, the molecules were bound together in relatively large structures. The structures grew smaller relative to their distance from the center. At the edges of the lens, the structures were made from just two molecules. This works for the squid, because the structures allow for bending light differently depending on which part of the lens is struck. The result is far more clarity under dim light conditions.

More information: Eye patches: Protein assembly of index-gradient squid lenses, *Science* (2017). science.sciencemag.org/cgi/doi …

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Abstract
A parabolic relationship between lens radius and refractive index allows spherical lenses to avoid spherical aberration. We show that in squid, patchy colloidal physics resulted from an evolutionary radiation of globular S-crystallin proteins. Small-angle x-ray scattering experiments on lens tissue show colloidal gels of S-crystallins at all radial positions. Sparse lens materials form via low-valence linkages between disordered loops protruding from the protein surface. The loops are polydisperse and bind via a set of hydrogen bonds between disordered side chains. Peripheral lens regions with low particle valence form stable, volume-spanning gels at low density, whereas central regions with higher average valence gel at higher densities. The proteins demonstrate an evolved set of linkers for self-assembly of nanoparticles into volumetric materials.