

# Trilobite eyes: An impressive feat of early

by Lisa J. Shawver

The most prevalent creature in the teeming Cambrian seas was the trilobite—a small segmented (three-lobed) marine arthropod resembling the wood louse. Although extinct for more than 300 million years, their fossil remains indicate that in one respect, the trilobites may have been superior to current living animals. They had, in principle, perfect vision: They possessed the most sophisticated eye lenses ever produced by nature.

This optical discovery was made by Riccardo Levi Setti, professor at the University of Chicago and at Enrico Fermi Institute, upon return from a trilobite conference this past summer in Oslo, Norway. There, he met E. N. K. Clarkson of the University of Edinburgh, Scotland, and discussed some of Clarkson's discoveries concerning the structure of trilobite eyes. Levi Setti returned to Chicago with some sketches of the lenses and with a conviction that he had seen the lens shapes before. While browsing through past scientific literature, he discovered in Christiaan Huygens' *Traité de la Lumière*, pub-

lished in 1690, and in René Descartes' *La Géométrie*, published in 1637, lens designs that looked nearly identical to Clarkson's sketches—designs of what are called aspheric aplanatic lenses, or lenses devoid of spherical aberrations.

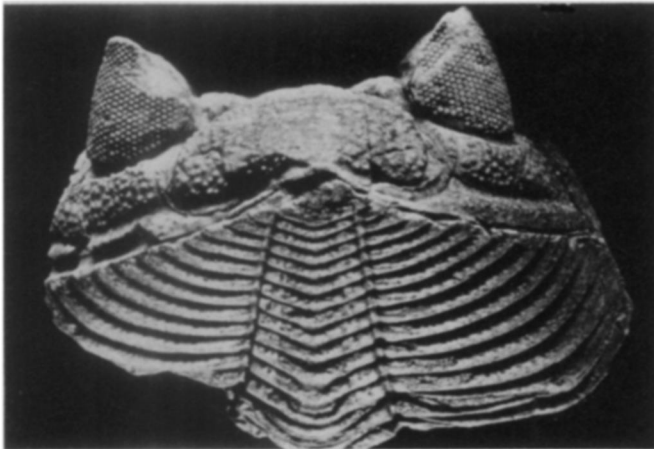
"Armed with the conviction that trilobites had solved a very elegant physics problem and knew about Fermat's principle, Abbe's sine law, Snell's law of refraction and the optics of birefringent crystal," writes Levi Setti in his forthcoming book, *Trilobites*, "I set out to inform Dr. Clarkson of the meaning of his trilobite's lens shapes."

Trilobites came in a diversity of forms and were widely distributed over the face of the earth. Some had a dozen eyes while others had none; some had heads while others were headless. It is thought that they resided on sandy or muddy bottoms, some on coral reefs or perhaps in the deep sea. They were so abundant in some localities that the rock strata are crowded with their remains.

As early as 1901, G. Lindström recognized that there existed two dif-

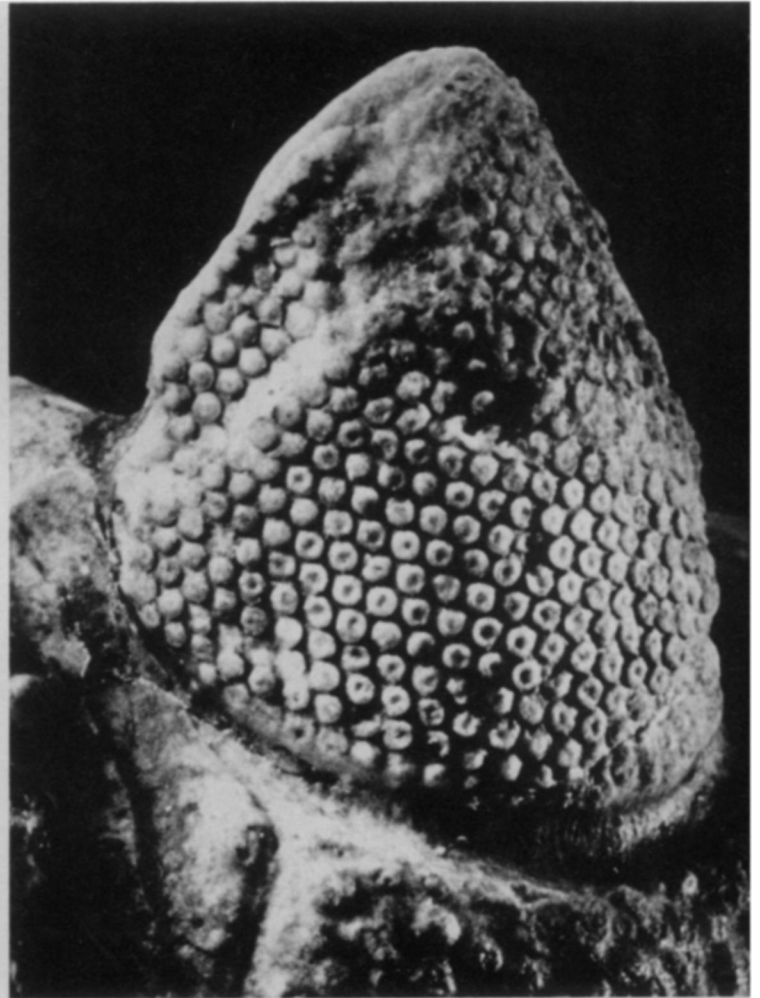
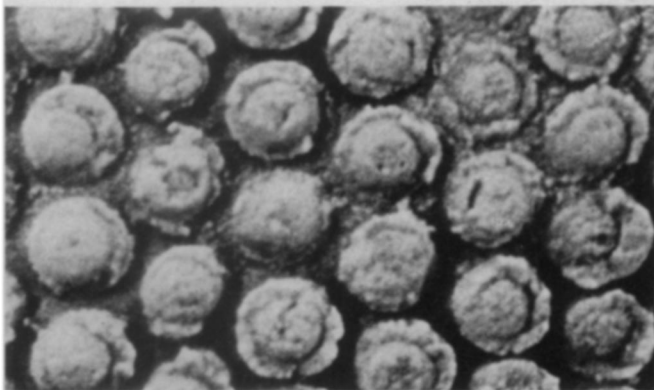
ferent kinds of trilobite eyes—a compound eye or holochroal eye and an aggregated or schizochroal eye. The compound eye is characterized by a close packing of each eye making up the whole, and the entire visual surface is covered by a cornea. In the schizochroal eye, the lenses are separately encased, covered by a cornea and positioned in cylindrical mountings. It is in this particular eye structure that the unusual lenses have been observed. The lens structure does not correspond to any found in modern arthropods, as it developed when trilobites were already a separate stock and doomed to extinction. Phacopid are the principle example of trilobites with schizochroal eyes.

Because the trilobites lived in water, very thick lenses were required to have enough convergence to bring a pair of rays to a point of focus, explains Levi Setti. The large spherical aberrations that are generally found in simple thick lenses are corrected in the phacopid by the presence of a doublet lens structure. The upper unit resembles Huy-



Above: Separated trilobite fossil that shows corrected lenses of Huygens variety. Most all lenses are complete. Right: Enlargement of the same specimen. Below: Magnified to 20X.

R. Levi Setti/University of Chicago Press



# evolution

gens' Cartesian ovals and served the dual purpose of ridding the image of spherical aberrations and of focusing most incoming light. The lower part, the intralensar bowl, was needed to bring peripheral-edge rays into focus. It is also possible, comments Levi Setti, that the thick lenses served as collectors of a lot of light—a necessary function, indeed, if the animals lived in muddy waters.

"Nature has developed a process of optimization, which in this case, produced these incredible sophisticated shapes," says Levi Setti. "It didn't happen by accident. It proves that evolution can produce this kind of thing . . . the lenses look like they were designed by a physicist."

Though the trilobites were lavished by nature with this great optical gift, there is no way to know whether the trilobites made full use of it.

"The lenses are very good but we don't know what kind of brain the animals had and if they used the information at all," Levi Setti told SCIENCE NEWS. "Even today, anyone can have perfect eyes and be blind. The brain does the decoding.

"For instance, in man, the lens of the eye is not particularly perfect. In fact, it would give very poor images, but the brain is so complex that it does all the corrections like a computer.

"The horseshoe crab seems to have eyes that give very nice images but no one has been able to find out what the animal does with the images. It seems that the nervous system is very primitive . . . it could be that there was once a function that was lost in these animals. The same may be true for trilobites."

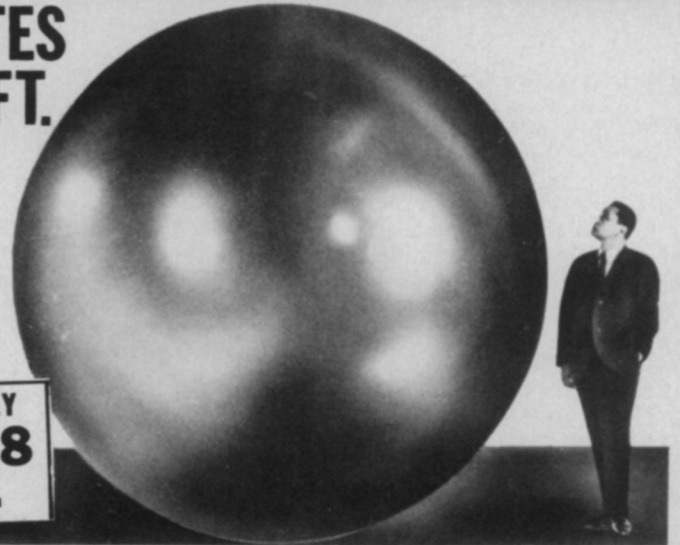
Another unusual aspect of trilobite eyes, uncovered last year by paleobiologist Kenneth M. Towe of the Smithsonian Institution, is that the lenses are made of precisely arranged crystals of the mineral calcite (SN: 3/10/73, p. 154). This is a fairly rare phenomenon. There are some crabs that utilize calcite, but in these instances the calcite is found in conglomerations. In the living trilobite, it seems the calcite was present in crystal form oriented in such a way that it produced the optical properties of glass and gave a relatively clear image over a wide depth of field.

Concludes Levi Setti: "The feat of trilobites in optimizing their optical apparatus is raising very revelant questions as to why such perfection was needed. Ultimately we may learn from this unusual evidence of past evolution, more about the neurophysiology of primitive invertebrates." □

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