Carmichael's Concise Review

Filling a Void in the Tree of Life with a Rare Fossil

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Understanding the tree of life requires placing fossils in the correct branch of that larger structure by determining the closest living relatives of extinct species. Arachnid fossils present special challenges because the environments where they live typically favor rapid decay, not allowing for burial and subsequent fossilization. In addition, many arachnids have poorly mineralized exoskeletons, which further hampers fossil formation. As a result, arachnid evolutionary history has many unresolved fundamental questions. Recently, Russell Garwood, Prashant Sharma, Jason Dunlop, and Gonzalo Giribet established the existence of a new suborder of harvestmen by reconstructing the microscopic anatomy of a new fossil species [1]. Harvestmen, more commonly known as daddy longlegs, are not spiders, although they closely resemble them.

Garwood et al. reported this Carboniferous (305 million years old) harvestman species, *Hastocularis argus*, on the basis of this study with microtomography (microCT) using X rays that provided a resolution as great as 6.6 µm, and then they reconstructed the specimen using special software. Comparisons to extant arachnids were made by examining the latter using scanning electron microscopy (SEM). The most notable feature of *H. argus* is the presence of four eyes, whereas living harvestmen have only two. Some extant arachnids have lateral eyes on the side of the body and a median pair near the midline. Harvestmen living today have only a single pair of eyes.

Garwood et al. corroborated their results by examining the expression of a particular gene associated with the growth of an eye-stalk in developing harvestmen embryos. The embryos briefly expressed this gene on their sides where eyes are located on the fossil. However, evidence of the associated lateral eyes disappear by the time they hatch. Taken together, the morphological and genetic evidence suggest that *H. argus* belongs to an extinct lineage closely related to the most primitive living harvestmen and that the last common ancestor of all living harvestmen had median and lateral eyes.

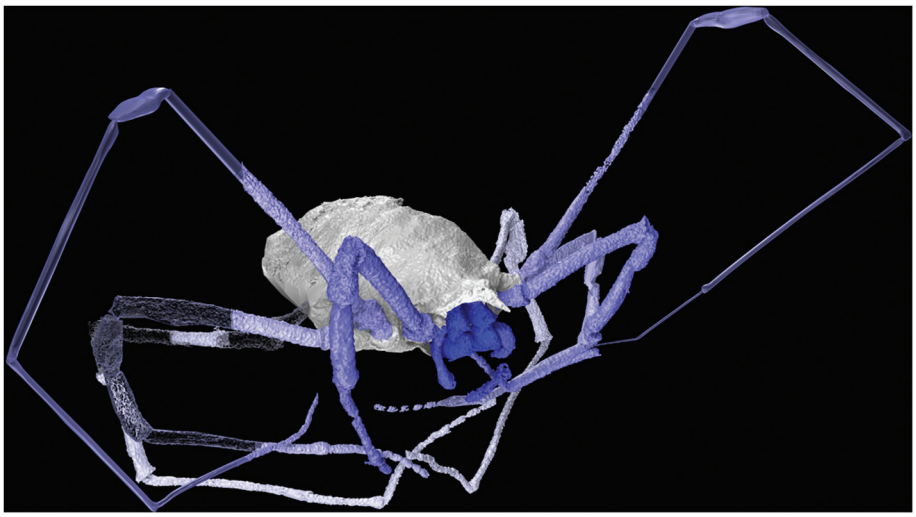

Figure 1: A 3D reconstruction of *H. argus* fossil showing the whole body and appendages.

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This discovery warranted a new suborder of harvestmen called Tetrophthalmi. The discovery of Tetrophthalmi alters molecular divergence time estimates. Specifically, a new DNA-based estimate suggests that living groups of harvestmen radiated during the Carboniferous rather than the Devonian period, that harvestmen as a group have their origins around 415 million years ago, and that arachnids came on to land sometime near 475 million years ago. This directly impacts conclusions that can be made for the tree of life in this arachnid order, and it also shows that by using a range of different methods of study, a single fossil discovery can have a great impact on our understanding of a group's evolutionary history and biology.

References

[1] Garwood, R.J., P.P. Sharma, J.A. Dunlop, and G. Giribet, A Paleozoic stem group to mite harvestmen revealed through integration of phylogenetics and development, Current Biology 24: 1–7, 2014.

[2] The author gratefully acknowledges Dr. Russell Garwood for reviewing this article.

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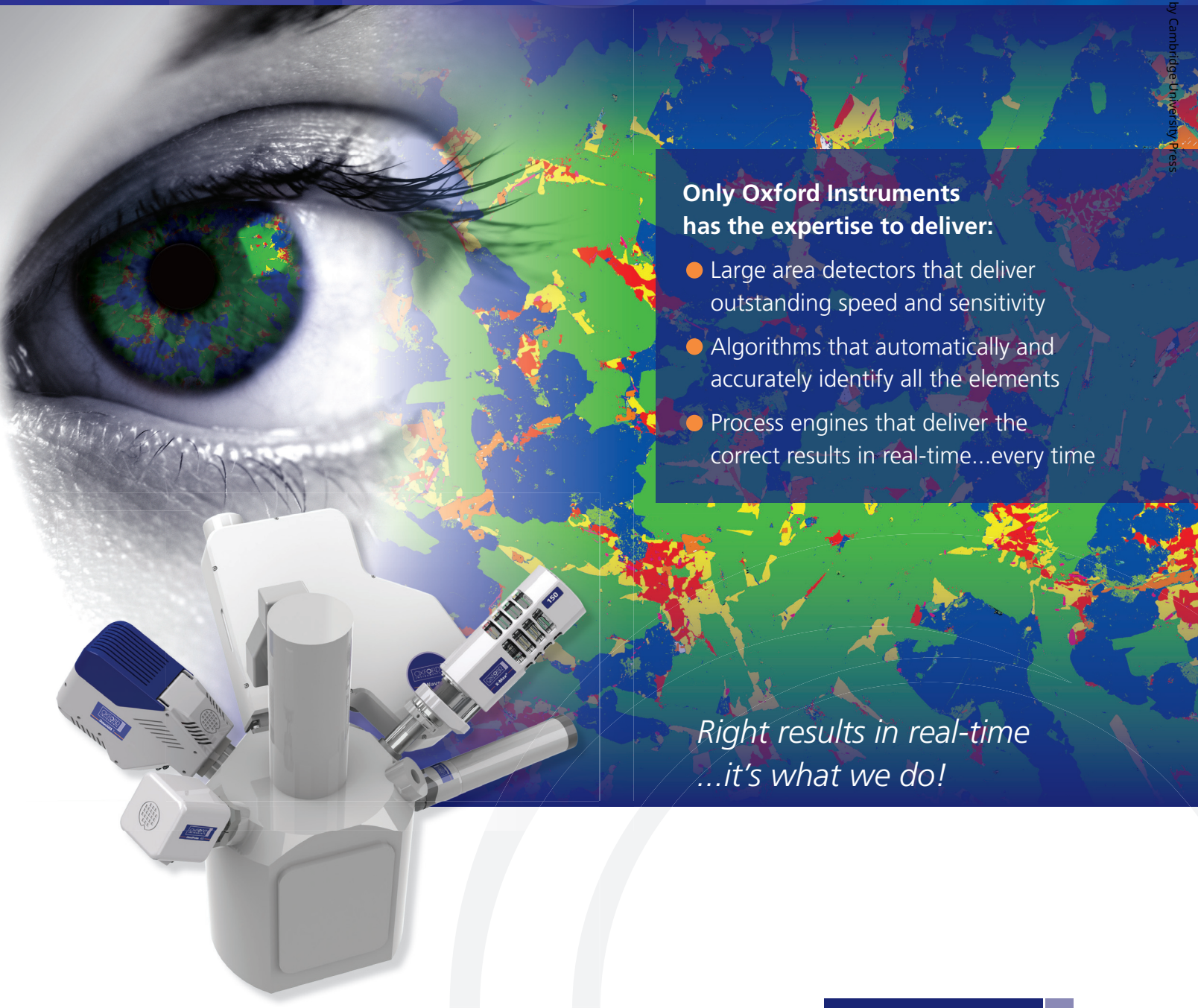

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