Sedgwick Museum
of Earth Sciences

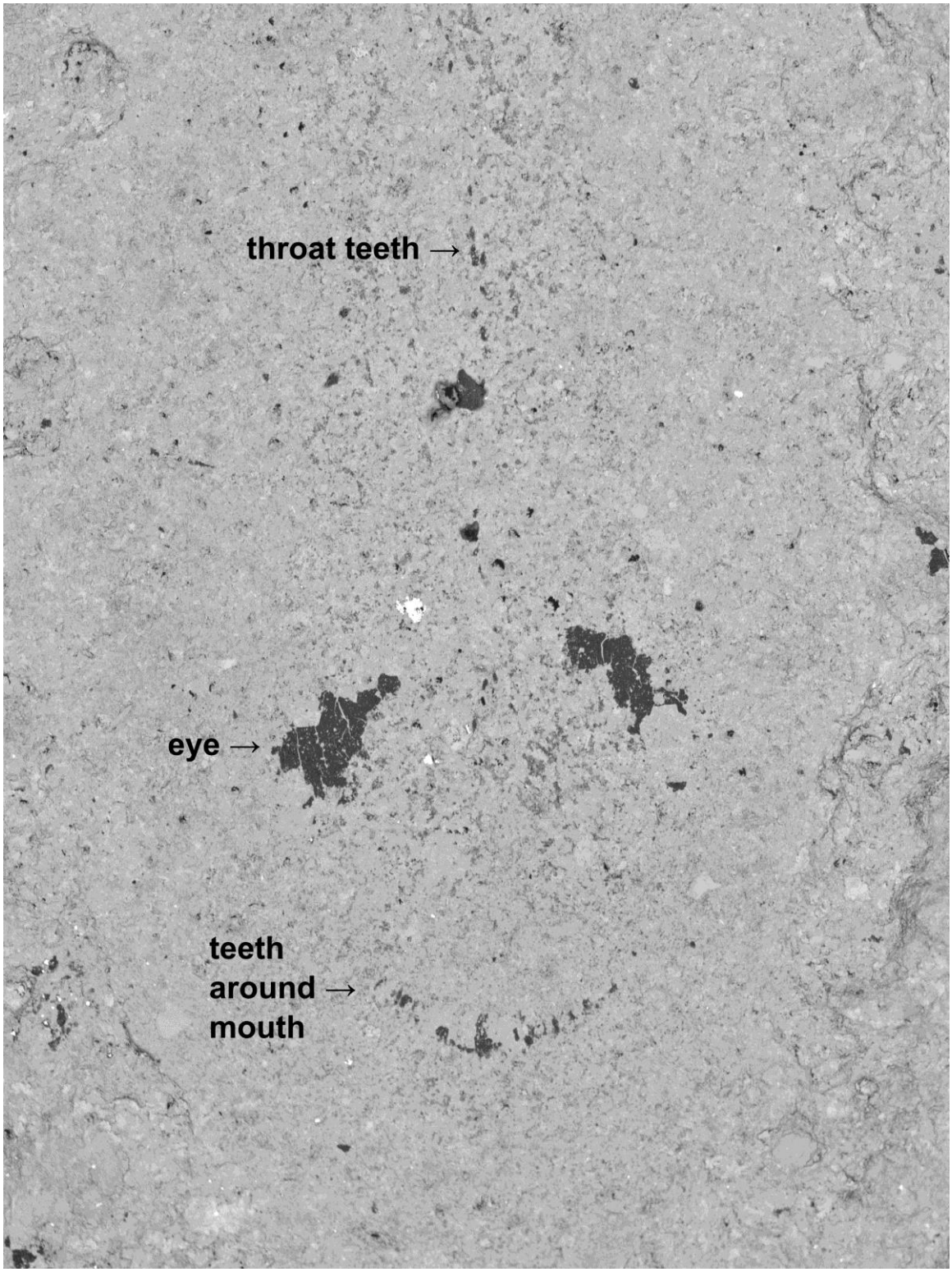
Hallucigenia 'plus teeth, plus eyes'

In a reversal of Shakespeare's famous finale to his melancholic monologue on the 'Seven ages of Man - sans teeth, sans eyes…' a most ancient fossil, appropriately named Hallucigenia has now been found to possess teeth and eyes, albeit of a primitive kind.

Coloured reconstruction of Hallucigenia showing the head with the newly discovered simple eyes (reconstruction by Danielle Dufault)

The flattened body of a 508 million year-old, 1.5cm long fossil of Hallucigenia is preserved on a rock surface from the Cambrian age Burgess Shale of Canada. A palaeontologist has carefully prepared the specimen to reveal as much detail as possible of the elongate soft body and legs along with the seven pairs of tougher protective spikes on the back and tiny claws at the end of the legs. The head is on the right and a faint trace of the gut can be seen extending along the body. (image courtesy of Jean-Bernard Caron)

In their latest detailed study of the 508 million year old fossil Hallucigenia (published in Nature June, 2015), Dr Martin Smith of the Department of Earth Science and his colleague Dr Jean-Bernard Caron of the Royal Ontario Museum have found some remarkable new anatomical details of the superficially caterpillar-like Hallucigenia. Smith and Caron have spotted microscopic arrays of hard tooth-like structures (10-60 microns in size) in Hallucigenia's throat and foregut regions along with traces of simple eye-like structures (200 microns wide) on the head.



High magnification electron microscope image of the flattened head of a Hallucigenia specimen seen from above, showing the miniscule eyes, circum-oral ('round-the-mouth') teeth, and pharyngeal ('throat') teeth. Field of view is 1 mm. (image courtesy of Martin R. Smith and Jean-Bernard Caron)

This discovery has far reaching implications for the evolutionary history of a whole group of early arthropod relatives, known collectively as the Ecdysozoa, and especially its earliest history, which until now has been a matter of considerable argument and speculation. The new evidence supports a true evolutionary relationship between the two major groups that

comprise the Ecdysozoa – panarthropods, such as the living velvet worms (onychophorans) and water bears (tardigrades), and cycloneuralian worms, such as the living nematodes and priapulids.

A 'mind bending' little fossil Hallucigenia certainly is, as its name suggests, a mind bending little fossil. First discovered in the Cambrian age Burgess Shale deposits of British Columbia just over 100 years ago, it was initially described by the eminent American palaeontologist Charles Walcott as a polychaete worm. Finding new specimens over the intervening years has had scientists puzzled and the strange little beast has been at times turned upside down, back to front and on its side. Finally, Hallucigenia has come to rest and has been assigned to a living group of arthropod-related velvet worms or onychophorans as they are technically known.

From the 100 or so fossil specimens available to them, Martin Smith and Jean-Bernard Caron have also been able to clarify the body form of Hallucigenia. Growing to around 50 mm long, the essentially soft-bodied animal has an elongate tubular form, only 4 mm wide, supported by 7 pairs of legs, each of which ended in tiny claws, along with another 3 pairs of thinner and clawless front appendages. Along the back there was an array of thin sharply pointed and slightly curved spikes (up to 12 mm long) for protection from any would-be predator. Whilst some of Hallucigenia's recently discovered characters have strengthened its links to the living onychophorans, the discovery of toothlike structures is more problematic as they are not found in the living forms. However similar structures are seen in other living panarthropods and cycloneuralians thus strengthening the evolutionary connection between the two within the larger grouping of the Ecdysozoa. Smith and Caron argue that the absence of toothlike structures in living onychophorans is most likely due to secondary loss over the hundreds of millions of years through which these living fossils have survived.

Apart from its taxonomic transformation over the last 100 years, Hallucigenia could hardly have had a more different lifestyle from its living relatives. From being seabed dwellers in Cambrian times, the onychophorans somehow became landlubbers, living amongst the leaf litter on tropical forest-floors. So far the evidence from the fossil record tells us that of this dramatic ecological shift and move from the seabed to freshwater swampy environments had happened by late Carboniferous times around 300 million years ago.

A display of fossils from the Burgess Shale including images of Hallucigenia is to be seen in the Sedgwick Museum.

Websites: Canada's Royal Ontario Museum (http://www.rom.on.ca/en) has a website dedicated to the Burgess Shale and its fossils, see http://burgess-shale.rom.on.ca/
Also see http://www.nature.com/nature/index.html

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