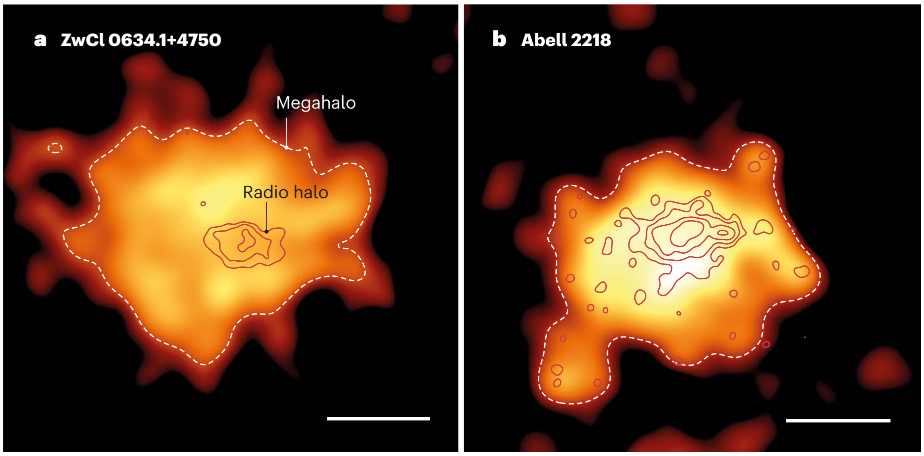

Figure 1 | A megahalo surrounding a galaxy cluster. Radio haloes are large volumes of ionized gas emitting radio-frequency radiation, and are found at the centre of galaxy clusters. In their survey of 310 galaxy clusters, Cuciti *et al.*[2] identified 4 clusters that had similar radio-emitting material far from the centre, in the outer regions of the clusters. The authors termed these sources megahaloes, and found evidence to suggest that their formation mechanism differs from that of typical radio haloes. Two of the four clusters are shown here: **a**, ZwCl 0634.1+4750; **b**, Abell 2218. Scale bars, 1 megaparsec. (Adapted from Fig. 1 of ref. 2.)

authors dubbed these haloes megahaloes, and noted that they had a much lower brightness profile and emissivity than do typical radio haloes (Fig. 1). These observations led them to conclude that, although the megahaloes are related to regular haloes, the two types of entity are distinct, and might therefore be formed by slightly different mechanisms.

Although Cuciti and colleagues' sample size is small, their findings show that relativistic particles and magnetic fields are present in a greater extent of a cluster than was previously thought. All four of the authors' clusters are characterized by high mass and low redshift, a measure of the change in emission wavelength that reveals how far the cluster is from Earth. That they all fall into this category prompted the authors to conclude that the mass of the cluster is related to the power of the megahalo, just as it is for conventional radio haloes. Whether this means that synchrotron emission is not generated on the outskirts of lower-mass clusters is perhaps a question that can be answered only once the SKA is fully up and running – it could simply be too faint to be detected with current instruments.

It is noteworthy that megahaloes were not observed in nine other clusters that met the same mass–redshift criteria as the four reported by Cuciti and colleagues. The authors reason that the data quality was too poor, or radio signals in the region too complex, to enable the observation of megahaloes around these nine clusters. Both issues could indeed hamper extraction of the large-scale faint emission from observations. However, the authors do not discuss whether the upper limits of megahalo detection in these systems are at odds with the rest of their observations.

The dynamic nature of the systems might also be a factor in the difficulty of observing megahaloes around low-mass clusters producing limited synchrotron power. Simulations have shown that not all galaxy-cluster mergers are created equal, and that the point at which the system is observed during a merger can also markedly affect the observable characteristics of diffuse emission[8]. Whether this is part of the reason that likely candidate clusters were not observed to have megahaloes is still to be investigated.

Cuciti *et al.* also used hydrodynamic cosmological simulations to probe the amount of energy produced by turbulence in different parts of clusters. Intriguingly, they found that the amount of turbulent energy in volumes that were commensurate with their observed megahaloes was similar in clusters that were undergoing merger activity and those that were not. This could indicate that the formation mechanisms for megahaloes do not rely on turbulence generated by mergers, and are therefore different from those driving the radio haloes embedded in clusters.

At this stage, the discovery of these megahalo sources poses more questions than it answers. But it opens up an exciting avenue for cluster studies at low emission frequencies, and offers further evidence of the scientific discoveries that lie waiting as our telescopes become more powerful and our data-processing techniques more advanced than ever before.

Kenda Knowles is at the Centre for Radio Astronomy Techniques and Technologies, Department of Physics and Electronics, Rhodes University, Makhanda, 6139, South Africa.
e-mail: k.knowles@ru.ac.za

1. van Weeren, R. J. *et al. Space Sci. Rev.* **215**, 16 (2019).
2. Cuciti, V. *et al. Nature* **609**, 911–914 (2022).
3. Cassano, R., Brunetti, G. & Venturi, T. *J. Astrophys. Astron.* **32**, 519–527 (2011).
4. Cassano, R., Brunetti, G. & Setti, G. *Mon. Not. R. Astron. Soc.* **369**, 1577–1595 (2006).
5. Knowles, K. *et al. Astron. Astrophys.* **657**, A56 (2022).
6. de Gasperin, F. *et al. Sci. Adv.* **3**, e1701634 (2017).
7. Venturi, T. *et al. Astron. Astrophys.* **603**, A125 (2017).
8. Donnert, J., Dolag, K., Brunetti, G. & Cassano, R. *Mon. Not. R. Astron. Soc.* **429**, 3564–3569 (2013).

The author declares no competing interests.

Palaeontology

Lifting the veil on the oldest-known animals

Marc Laflamme

Gaps in the fossil record mean that the origins of ancient animals such as jellyfish and corals have remained a mystery. Now, a long-awaited fossil discovery reveals key features of this group during the early stages of its evolution.

Jellyfish and corals belong to the group of animals known as cnidarians. The oldest-known ancestors of this grouping are thought to have arisen by the Ediacaran period (between 635 million and 539 million years ago); however, fossil examples of cnidarians have been lacking. Writing in *Nature Ecology & Evolution*, Dunn *et al.*[1] report the discovery of a fossil cnidarian from Charnwood Forest in the United Kingdom. If this attribution is correct, the species – which the authors named *Auroralumina attenboroughii*, in honour of the natural historian David Attenborough – has a body plan that is very different from that of other Ediacaran organisms. Its architecture is instead much more reminiscent of younger forms derived from a subsequent event called the Cambrian explosion, which underpinned the evolution and diversification of most modern groups of animals.

In the continuing effort to explain the origins and early evolution of animals, fossils such as *A. attenboroughii* (Fig. 1) are pivotal resources for providing key divergence times for phylogenetic studies, which seek to construct evolutionary trees by using an approach called a molecular clock. However, given that this discovery is limited to a single, poorly preserved specimen among many other exceptionally preserved Ediacaran fossils, it is important to consider the anatomical characteristics on which subsequent phylogenetic interpretations should be based.

The fossils from Charnwood Forest hold a special place in the study of Precambrian life, because they represent some of the oldest examples (from 562 million to 557 million years ago) of the 'Ediacara biota' – a group of globally distributed and temporally restricted organisms whose place in the tree of life remains controversial despite nearly a century of research. To some, the organisms in the Ediacara biota represent early animals and thus are forerunners of the forms that make up our present-day biosphere. At the other extreme, some argue that the organisms represent long-extinct lineages that left no descendants after the Ediacaran period, and thus are early evolutionary experiments in multicellularity.

As with many things, the answer might lie somewhere in between. Studies looking at evidence such as fossilized animal trackways[2,3], developmental data[4] and biomarkers[5] firmly establish the presence of animals in Ediacaran-aged ecosystems. However, certain examples of Ediacara biota, such as extinct organisms called erniettomorphs and rangeomorphs, are hard to reconcile with any animal groups, owing to their strange anatomy, which is unlike that of any known animal.

Ediacaran fossils from Charnwood Forest were first reported in the 1950s by the UK palaeontologist Trevor Ford[6], who was given a series of surface etchings by Roger Mason, a local schoolboy after whom an Ediacaran fossil frond, *Charnia masoni*, is named. Given that these organisms lacked mineralized hard parts such as teeth, bones and shells, their preservation was achieved through casting by volcanic ash – a Precambrian Pompeii. In some cases, the level of preservation is astounding, enabling submillimetre-scale anatomical features to be discerned. However, if too much organic decay had occurred before the preservation of the fossil impression, features of the fossil shape become difficult to interpret. Furthermore, fossil casting essentially transforms a 3D organism into a 2D impression, resulting in the overprinting of features as distinct elements become superimposed. Thus, the interpretation of anatomical details associated with soft-bodied Ediacaran fossils is no trivial task.

In the case of *A. attenboroughii*, Dunn *et al.* contrast two distinct states of preservation to infer differences in tissue strength before fossilization: a smooth (presumably more decay-resistant), goblet-shaped structure called a periderm; and a jumbled mass of more-decay-prone tentacles called the crown, which emerges from the periderm. Crucially, the presence of two distinct goblets fossilized in two different orientations following burial – one lying flat and the second on its side – enables Dunn *et al.* to infer that the goblets were originally four-sided, with a strong groove running along the middle of each facet of the goblet. This construction is reminiscent of organisms called conulariids, which have been interpreted by some as being what are known as medusozoan cnidarians. This interpretation of the anatomy thus places *A. attenboroughii* firmly in the world of animals, and in the pantheon of organisms that we know and understand.

Moreover, the fossil's discovery has ramifications for our understanding of Ediacaran ecosystems, particularly in terms of the presence of different modes of feeding. If Dunn and colleagues' interpretation of its anatomy is correct, then the fossil represents a notable divergence from conventional interpretations of Ediacaran-style feeding, which many still assume was dominated by a mechanism called osmotrophy – a relatively simple method of gathering nutrients that revolves around the absorption of organic matter across tissues. The earliest ancestors of cnidarians are thought to have been predatory, like modern cnidarians, which suggests that *A. attenboroughii* would have been a predator sitting on the ocean floor approximately 30 million years before this behaviour is thought to have become more widespread in animals. What could this animal have been feeding on with its tentacles, and what consequences would the introduction of predatory animals have had on osmotrophic Ediacaran ecosystems? As with most descriptions of Ediacaran fossils, Dunn and colleagues' work raises as many questions as it answers.

However, in the absence of supporting material, all anatomical inferences are restricted to this single specimen, and the range of preservation of these features cannot be explored, nor is it easy to understand the animal's original 3D anatomy from the fossil remains alone. Therefore, *A. attenboroughii* highlights the difficulties presented by an imperfect fossil record when trying to get a clear view of animal evolution at a time when the earliest animals were peeking from behind the curtains of a fantastical world of oddities and curiosities.

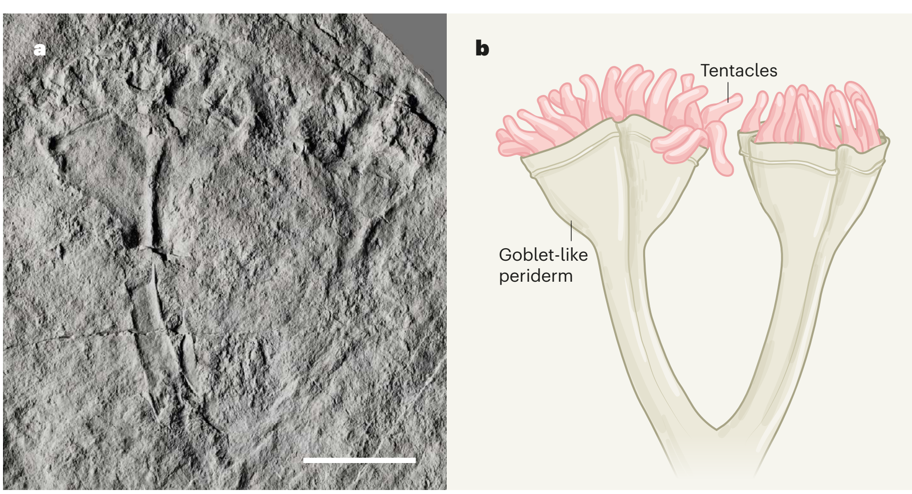

Figure 1 | *Auroralumina attenboroughii*. a, Dunn *et al.*[1] present a fossil of the earliest-known member of the cnidarian group, which includes jellyfish and corals. This species is estimated to be between 562 million and 557 million years old (a time frame in the Ediacaran period), and it sheds light on the earliest-known stages of animal evolution. **b**, The specimen has tentacles and goblet-like structures that arise from tissue called the periderm. Scale bar, 5 centimetres. (Figure adapted from Figs 1 and 4 of ref. 1; CC BY 4.0.)

Marc Laflamme is in the Department of Chemical and Physical Sciences, University of Toronto Mississauga, Mississauga, Ontario L5L 1C6, Canada.
e-mail: marc.laflamme@utoronto.ca

1. Dunn, F. S. *et al. Nature Ecol. Evol.* **6**, 1095–1104 (2022).
2. Evans, S. D., Gehling, J. G. & Droser, M. L. *Geobiology* **17**, 490–509 (2019).
3. Turk, K. A., Maloney, K. M., Laflamme, M. & Darroch, S. A. F. *J. Paleontol.* **96**, 753–769 (2022).
4. Dunn, F. S., Liu, A. G. & Donoghue, P. C. J. *Biol. Rev.* **93**, 914–932 (2017).
5. Bobrovskiy, I. *et al. Science* **361**, 1246–1249 (2018).
6. Ford, T. D. *Proc. Yorks. Geol. Soc.* **31**, 211–217 (1958).

The author declares no competing interests.
This article was published online on 13 September 2022.