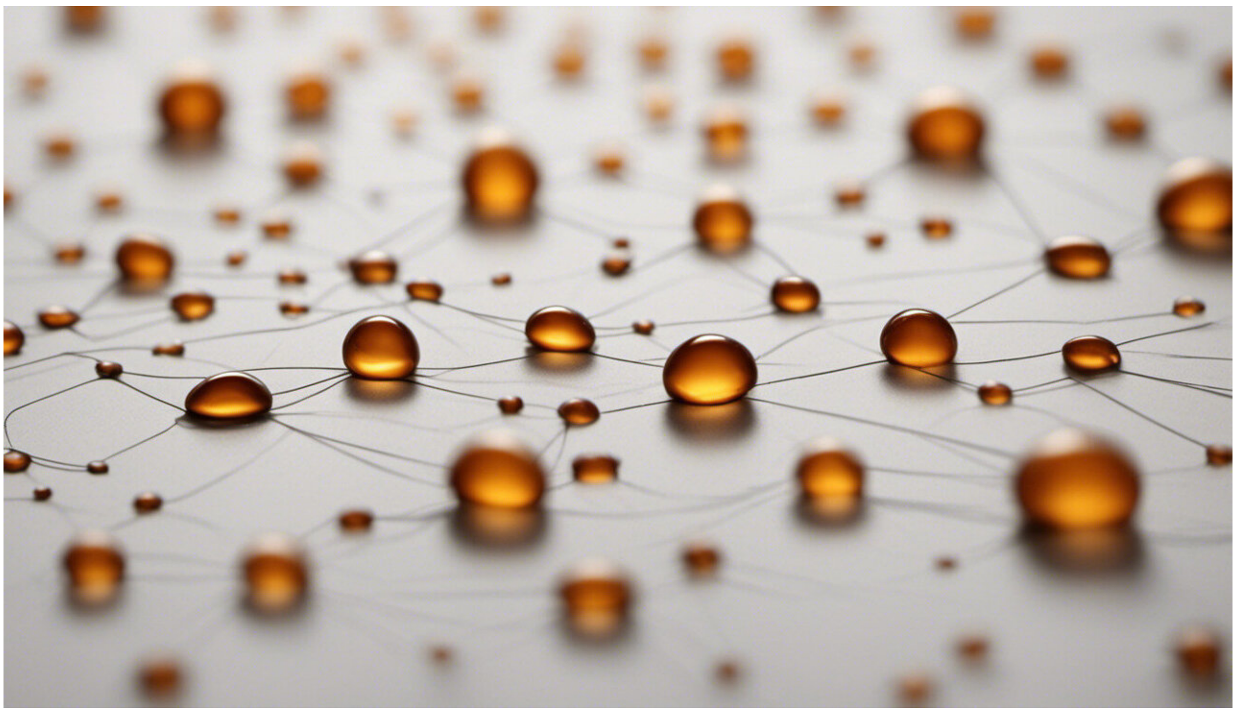
How animals went from single cells to over 30 different body types

September 4 2018, by Jordi Paps



Credit: AI-generated image (disclaimer)

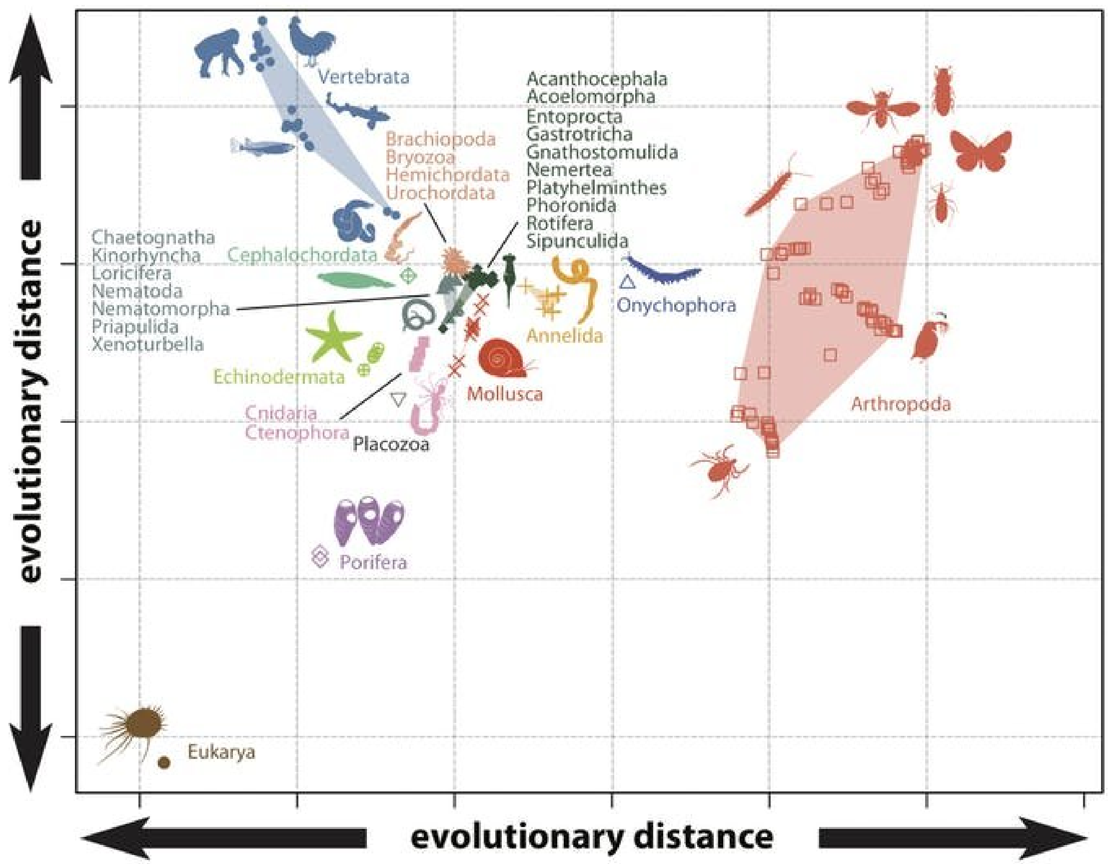
Whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.

So wrote Charles Darwin, in his On the Origin of Species. The origin and evolution of animals is one of the most fascinating questions in modern biology. We know that the entire wonderful variety of animals alive today arose from single-celled ancestors. And we know that this transition was likely related to the planet's environment and how organisms interact with it, as well as changes in their genetic material (genome).

But we don't know if the diversity of animal shapes, those "endless forms most beautiful and most wonderful" that Darwin described, emerged quickly after the first animal lifeforms or whether it came much later in their evolution. A team of evolutionary biologists from the UK and the US have tried to tackle this question in a most beautiful and most wonderful paper published in the scientific journal *PNAS*.

The authors analysed numerous animal anatomies using sophisticated statistical methods. Their results showed that most animals groups reached their peak of anatomical diversity very early, but in a few cases, this still increased afterwards. They also found the most likely causes for these variation patterns.

Animals display different anatomical bits, each with a large diversity of forms and shapes. For example, insects have a head and six legs, while sea anemones do not. The combination of these features is called bodyplans, which are often used to group animals in categories called phyla. Examples of modern phyla include arthropods (spiders, centipedes, crustaceans, insects, and others), chordates (vertebrates and some invertebrate allies), molluscs (snails, octopodes, and others), and annelids (earthworms and leeches among others).



Animal groups mapped according to diversity. Credit: Philip Donoghue

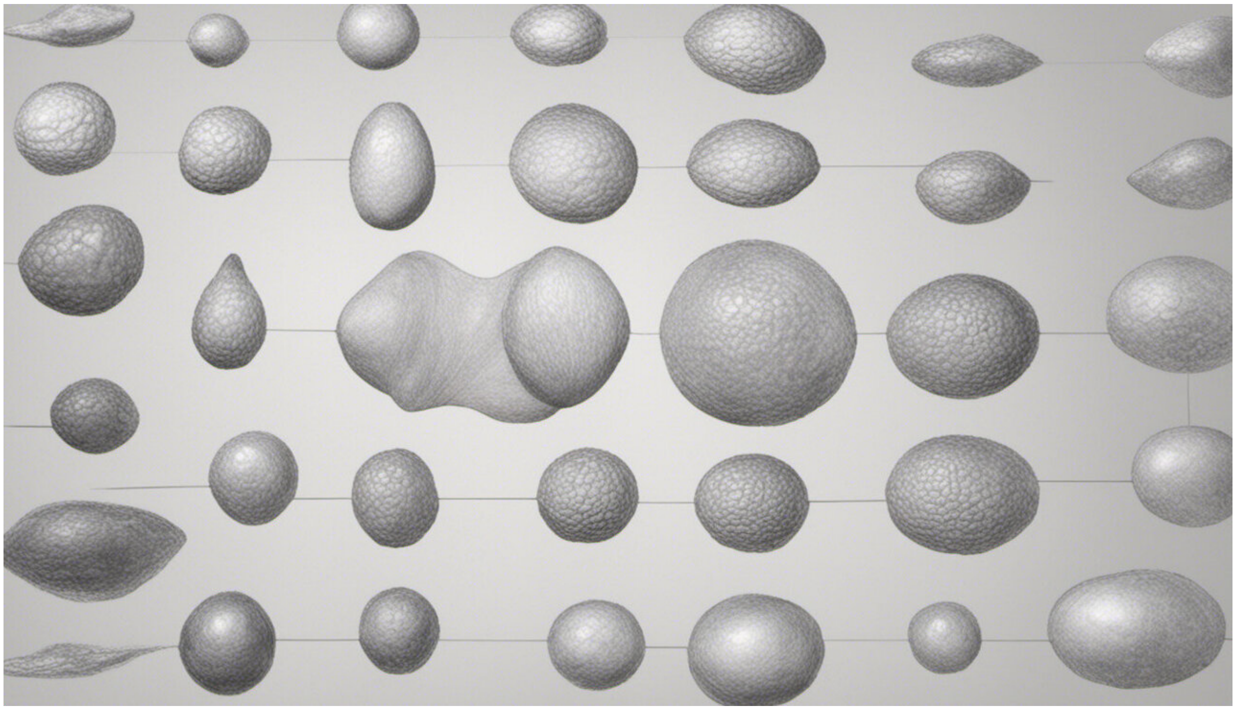
Nowadays there over [30 animal phyla] and some display a larger range of forms (known as disparity) than others. For example, chordates comprise animals as disparate as a fish and monkeys, while roundworms (phylum nematodes) are less disparate and look pretty much all the same.

The researchers wanted to resolve how this disparity, among groups and within groups, evolved. They collected anatomical data for nearly 2,000 anatomical features for 210 animal groups, sampling many groups within each phylum. Then they analysed their anatomical similarity with cuttingedge statistics. These produce a map of sorts, in which each group is a dot and the distance among groups is proportional to their anatomical similarity.

Their results show that the groups within each phylum neatly cluster together in the map, as expected by their shared bodyplans. For example, in the map spiders are closer to insects and other arthropods, while fish are closer to mammals and other chordates. The map area occupied by the members of a phylum indicates how anatomically diverse this phylum is. Vertebrates and arthropods show the largest areas of them all.

Continued evolution

Remarkably, most phyla reached their levels of disparity very shortly after the origin of animals, except four phyla that kept on expanding. These are arthropods, chordates, molluscs, and annelids, which have some members that transitioned from water to land later during evolution. Moving onto land confronted them with new challenges that led them to evolve new types of body parts.



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What's more, these living phyla are very different from each other, with large empty map areas among them. But when fossils of extinct groups are added to these analyses the gaps among the different phyla are reduced. This suggests that early animals were not that disparate as they look today. Early animal evolution explored many different anatomical possibilities, but the extinction of some bodyplans exaggerates their differences.

Finally, the researchers tried to find if there was an association between animal disparity and other biological traits. They found that the greater the disparity in a phylum, the greater the number of cell types, body size and number of species.

There is also a correlation with the genome size, but not with the number of protein-coding genes in the genome. We know that some parts of the genome are dedicated to regulate when and where the body's proteins will work, rather than making the proteins themselves. The paper's authors argue that if the level of disparity correlates with the size of a phylum's genome but not the number of genes within it, then this means that gene regulation played a greater role in animal diversity than the emergence of new genes did.

This study has painted a new picture of animal origins, in which most animal phyla explored their anatomical diversity early on, but the transition from water to land led a few phyla to explore new areas of the disparity map. Animals were originally more homogenous, and the modern differences are product of the extinction of some intermediate groups.

All these disparate disparities are heavily correlated with the evolution of gene regulation. More anatomical data, more fossils, and the further study of gene regulation will be essential to further our understanding of the animals' endless forms most beautiful and most wonderful.

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