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Animal genomes: Chromosomes almost unchanged for over 600 million years

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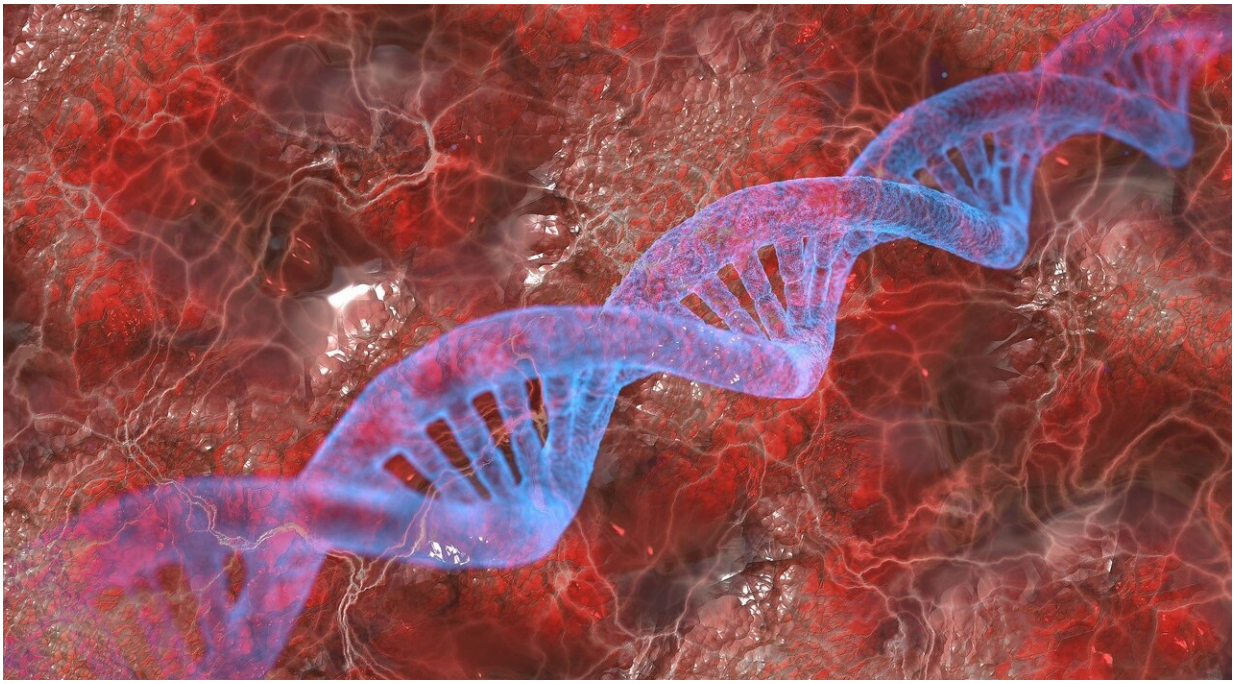

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By comparing chromosomes of different animal groups scientists at the University of Vienna led by Oleg Simakov and at the University of California made an astonishing discovery: Every animal species has almost the same chromosomal units that appear over and over again—and this has been the case since the first animals emerged about 600 million years ago. Using new principles, human chromosomes can

now also be dissected into these primordial "elements." The new study has just been published in the journal *Science Advances*.

Animal diversity is fascinating, but how is this reflected in their genetic material, the genome? Is it possible to definitely distinguish animals from one another based on genetic information, and perhaps even make predictions about how genetic information changes over time? This has been the great hope since the beginning of the "genome era" in 2000, when the human genome was sequenced for the first time. More than 20 years later, scientists now have access to technologies that can reveal the complete sequence of entire chromosomes that comprise the genome. Before, they could only study smaller fragments of chromosomes.

In their new study, the researchers compared chromosomes from different animal groups. Their conclusion: every animal species has almost the same chromosomal units. These chromosomal units, also called "elements," have remained constant in evolution, so that genomes of almost every animal can be represented exactly by listing the combinations of these basic building blocks.

Genomic diversity through mixing of these elements

Although these chromosomal elements remain constant during evolution, they can mix in different ways. The researchers succeeded in classifying these mixtures and deriving general principles that can be viewed as simple mathematical formulas. Until then, it was only possible to determine how many chromosomes an animal had, but not which ones exactly and their evolutionary history. "So now, for example, we can break down each human chromosome into its elements using algebraic notation. Then we deduce what happened to these primordial elements in different species and genera such as corals, molluscs, birds and many others, and what new chromosomes these elements had assembled into," explains molecular biologist Oleg Simakov from the University of

Vienna.

Mixing of elements is irreversible

Another finding from the study: the individual chromosomal elements never return to their original, separate state once they have mixed together to form a new chromosome. "Such events are irreversible in evolution and every group of animals—from corals to humans—has such unique combinations that will forever distinguish the descendants of these groups and set these groups apart from others," Simakov said.

The researchers were also able to determine the origin of many animal chromosomal elements and show that the single-celled organisms most closely related to animals have only a few of these elements—many elements therefore only evolved in the very first animals. Why the chromosomal elements are so well conserved, what role the mixing of the elements might play in evolution and many other questions remain open and are still being researched.

More information: Oleg Simakov et al, Deeply conserved synteny and the evolution of metazoan chromosomes, *Science Advances* (2022). DOI: 10.1126/sciadv.abi5884. www.science.org/doi/10.1126/sciadv.abi5884

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