

How humans' capacity for cultural adaptation allowed them to spread across the planet

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29 March 2026

It is a basic understanding in anthropology that the course of human evolution differs fundamentally from that of other animals due to its heavy reliance on cultural rather than biological adaptation. Culture is learned behavior that is passed on between members of a group and from one generation to the next by imitation and/or active teaching rather than by genetic inheritance.

While a number of species, most notably our closest ape relatives, exhibit some rudimentary culture, humans are totally dependent on language, technology, complex social organization and the like for survival.

Of course, the ability to learn new behaviors is dependent on biological capabilities which are subject to natural selection. Humans and their ancestors have, over millions of years, developed a capacity for culture that is qualitatively different from that of any other species, based on abstract symbolic thought and characterized by open endedness. Humans have the ability to learn and execute complex sequences of steps to accomplish an ultimate goal. These steps or subgoals are “modular” in the sense that they can be employed individually to accomplish a number of different tasks. Furthermore, they can be creatively recombined in novel sequences to meet new needs.

Based on this highly enhanced capacity for culture, humans have spread more widely across the globe, inhabiting a greater variety of environments, than any other vertebrate species. Newly published research (Perreault, 2026, PNAS, “Cultural evolution accelerated human range expansion by more than two orders of magnitude”) compares the range of ecological settings occupied by humans with those of a range of other mammalian species, demonstrating the qualitative

advantage conferred on humans due to their unique capacity for culture.

The new study uses a quantitative approach to empirically analyze the number of environmental settings inhabited by humans as opposed to occupied by a variety of terrestrial mammalian species. The focus on the latter is intended to reduce the range of uncontrolled variables that may bias the results (i.e., to compare “apples” to “apples”).

The advantage of cultural evolution over biological evolution rests in the fact that the former allows adaptation to novel environments much more quickly and effectively than the latter. Biological evolution is based on the relative success in reproduction by individual members of a species whose genetic makeup is more or less suitable for survival in a new environment. This may take many generations and is reliant on the existence of genetic variants within the subject population which confer enhanced reproductive success. If such genetic variants do not exist, no amount of natural selection will result in successful adaptation to the new environment (i.e., evolution will not occur).

By contrast, cultural evolution is much more flexible and rapid. In addition to biological adaptations, the author notes:

... humans can also adapt culturally to their environment. Humans can learn from others, giving rise to a secondary inheritance system. Cultural evolution is a population-level process in which social learning among individuals and improvements across generations produce technological and behavioral adaptations, including social norms that sustain large-scale cooperation. These cultural adaptations can

emerge without genetic changes, since cultural evolution operates on faster timescales than genetic inheritance.

Cultural adaptations are evident early in the history of genus *Homo*. *Homo sapiens* “emerged as a single species approximately 300 thousand years ago (kya) and has remained a single species but also one that is genetically less diverse than a single population of wild chimpanzees.” By 70 kya, modern humans in Africa had achieved significant ecological niche diversification. By 60 kya, modern humans had begun moving into Eurasia. And by 50 kya, humans had reached Australia. This sequence represents a remarkably rapid adaptation to a wide variety of environments, including arid deserts, high-altitude plateaus, savannas, temperate forests, coastal margins, tropical jungles and polar tundra.

How does this compare with the geographic/environmental distribution of other animal species?

Using data derived from studies of the environmental adaptations of nearly 6,000 species of terrestrial mammals, grouping these at the genus and higher taxonomic levels and correlated these with their respective environmental distributions, Pereault determined that if humans had relied on biological evolution alone to reach their present geographic and environmental distribution, it would have taken tens of millions of years, and resulted in the evolution of thousands of separate species with a wide range of body sizes.

In fact, the distribution of human populations in almost every terrestrial environment on earth demonstrates that humans accomplished this development over a time span of less than a million years, which is two orders of magnitude faster and with a minute fraction of the physical variation. He concludes that the capacity for cultural evolution is the key to this difference.

Further analysis of the micro-environmental adaptations of a range of cultural-linguistic human groups found that the capacity for fine-grained cultural adaptations has enabled humans to successfully occupy a wide range of specific ecological settings while at the same time maintaining the flexibility to rapidly adapt to new environments.

He writes: “As a result, human groups can specialize

in local environments without requiring geographic isolation [usually required for speciation in order to significantly reduce or eliminate gene flow between populations], even in densely populated regions. Thus, ethnolinguistic groups—defined by shared language and close social ties that maintain high-fidelity cultural transmission—should occupy smaller and therefore more ecologically specific ranges than biological species.”



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