“Human Origins 2021”

Sergey Gavrilets (1,4), Peter J Richerson (2), and Frans de Waal (3)

- (1) Department of Ecology and Evolutionary Biology, Department of Mathematics, National Institute for Mathematical and Biological Synthesis, Center for the Dynamics of Social Complexity, University of Tennessee, Knoxville, TN 37996;
- (2) Department of Environmental Science and Policy, University of California, Davis, CA 95616;
- (3) Living Links, Yerkes National Primate Research Center, Emory University, Atlanta, GA 30322;
- (4) Corresponding author; email: gavrila@utk.edu

“It has often and confidently been asserted, that man's origin can never be known: but ignorance more frequently begets confidence than does knowledge: it is those who know little, and not those who know much, who so positively assert that this or that problem will never be solved by science.” (Darwin “The Descent of Man” 1871, p.3).

“The difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind.” (p.85)

“The formation of different languages and of distinct species, and the proofs that both have been developed through a gradual process, are curiously parallel...” (p.90)

“A tribe including many members who, from possessing in a high degree the spirit of patriotism, fidelity, obedience, courage, and sympathy, were always ready to aid one another, and to sacrifice themselves for the common good, would be victorious over most other tribes... [A]s morality is one important element in their success, the standard of morality and the number of well-endowed men will thus everywhere tend to rise and increase.” (p.148)

We now have a much better understanding of how new species arise and adapt to their environments - the process which Charles Darwin called a “mystery of mysteries” - and we have begun to offer evolutionary accounts of the origin of our own species. Studying human origins necessarily implies a comparison with our close relatives, the other primates, and with other social animals. Here we argue that research on human origins and our subsequent cultural and social evolution is vital not only for foundational scientific discovery but also for understanding, mitigating, and solving *the most pressing challenges faced by our society*. Advancing research on human origins and social complexity is also very timely given *recent advances and emerging opportunities*. Fully capitalizing on these requires a concerted *transdisciplinary effort* of researchers from a diverse set of disciplines. Success in this endeavor could yield tremendous gains for society.

Challenges faced by our society. Understanding modern human behavior, psychology,

culture, and many economic, political, and social processes is hardly possible without also considering forces that have shaped our evolution (1). For example, humans strongly react to inequality and injustice, a behavior that we share with other primates (2). Understanding the evolution of our sense of fairness may help us build a more just society. Similarly, studies of sexual selection as well as genetic and cultural diversity can shed light on gender, race, and ethnicity-related prejudices, their consequences for human behavior, and ways to mitigate undesirable effects.

The genetic, physiological, and psychological “machinery” for our decision-making has evolved over time, shaped by forces like benefits and costs considerations, social instincts, cognitive biases, beliefs, normative values, reinforcement, and the “theory of mind”. Insights into the factors shaping human (pro)sociality can be leveraged to improve the efficiency and benevolence of collective actions in businesses and communities. They can foster more efficient economic, political, social, and educational policies. Such insights can also be applied to better understanding of motivations leading to the onset and maintenance of (non)violent conflicts, which can increase societal resilience to external and internal shocks.

Evolutionary processes have also shaped human psychology influencing various aspects of our social life. Examples include religion and rituals, arts, sports, and entertainment, activism and citizenship, leadership and followership, and the acceptance of or resistance to various innovations - cultural, economic, technological, and political. Heavy reliance on cultural learning throughout our evolutionary history explains conformity and overimitation as well as vulnerability to fake news and propaganda. Understanding and managing societal changes will hardly be possible without taking all of these aspects into consideration (3).

Our long-term persistence requires addressing existential risks from climate change, biodiversity loss, depletion of non-renewable resources, and security threats posed by unstable political systems. Humans have evolved various psychological mechanisms and biases for making collective decisions which need to be considered when developing policies for sustainability (4). There are also various public health issues, including emerging epidemic diseases, addictions, obesity, and geriatric disabilities, approaching which is already benefiting from application of the emerging discipline of evolutionary medicine (5).

Artificial intelligence (AI) is rapidly becoming a pervasive fact of all of our lives. It brings not only technological advances but also threats that are difficult to predict. Research on human brain and decision-making can be crucial in improving this technology. Simultaneously improving human-AI interactions requires a new look at human social psychology and on how we deal with various social dilemmas (6).

Recent scientific advances. There has been an exciting cascade of recent discoveries related to human origins and evolution. We illustrate a large arc of progress with examples from primatology, paleoclimatology, brain evolution, genetics, social, and cultural evolution. New transcriptome sequencing methods are allowing us to study the molecular and cellular differences in brain organization between human and nonhuman primates (6). Analysis of dynamic patterns of coordinated and anti-coordinated functional magnetic resonance imaging signals moves us closer to understanding the mechanistic correlates of consciousness (7). The capacity for cumulative culture has been crucial for the success of our species (3) but cultural transmission of habits and knowledge is clearly not limited to humans as it is now being studied

in animals including flies, fish, birds, primates, and whales (8). The concept of “theory of mind” comes out of ape studies in the 1970s, and after a period of doubt whether apes actually possess this capacity, it now seems that they understand that others’ actions are driven not by reality but by beliefs about reality, even if those beliefs are false (9). Paleoclimatological and paleoecological investigations are giving us an increasingly high-resolution understanding of the Pleistocene environments in which recent human evolution took place (10). Genomic and archeological studies are shedding further light on more recent events in human evolution, such as hybridization between our ancestors and Neanderthal and Denisovans, the spread of agriculture and pottery in prehistoric Europe, and population replacement in remote Oceania (1). These studies show a complex interplay of population migrations and the diffusion of cultural ideas across geographic landscapes. Archaeological and historical investigations increasingly produce sufficiently detailed time series that can be used to test sophisticated models of cultural evolution (12). Experimental economics points to the crucial importance of social norms for human cooperative behavior (13); compliance with norms is conditional on the fact that others comply and are willing to punish free-riders. Neuroeconomic studies of lesion patients with damage to different brain regions is allowing insights on the relative roles of intuition and deliberation in human cooperative behavior (14). Cumulatively these and other advances give us a feeling that different pieces of a huge puzzle are starting to come together.

Opportunities for further advances. Capitalizing on recent advances can further the development of a unified theory of human origins and evolution. This can be more readily achieved by leveraging existing and growing public interest. Arguably, no area of life sciences is more compelling to the general public, as understanding of human origins and evolution underpin discussions of our place in the universe, of cognition and morality, and of our fate as a species.

Mounting a concerted push now would be particularly meaningful, as a rather unique opportunity is rapidly approaching. Some may remember the widespread celebration of the 150th anniversary of Darwin's book “On the Origin of Species” in 2009, when a great number of conferences, workshops, new books, and public lectures celebrated the achievements of evolutionary biology and related aspects of the life sciences. These events garnered a tremendous amount of attention from the general public, traditional and new news media, politicians, and educators across the world. In 2021, we will be celebrating the 150th anniversary of Darwin's book “The Descent of Man”, in which he laid down the foundation for scientific studies of human origins. This book also introduced the concept of sexual selection, which continues to generate scientific insights of great interest and excitement to the general public including many that relate to dating, parenting, same-sex behavior, arts and intelligence. We anticipate that celebratory events similar to those in 2009, but on a larger scale, will be undertaken in 2021, as it will be a unique occasion to advance the appreciation of science in general, of life and social sciences, in particular, and of a diversity of topics related to human origins and evolution. Accordingly, we expect that 2021 will be replete with fantastic possibilities for education and outreach. Preparations should begin now to fully realize the potential impact of the anniversary.

Going forward. Inquiry into human origins and evolution is among the greatest scientific

challenges we face. Disciplinary pursuits can achieve singular discoveries, but more must be done. To move beyond the proverbial blind men's description of an elephant, we must blaze a new pathway forward through transdisciplinary collaborations of environmental scientists, biologists, social scientists, and theoreticians. We must build on emerging trends in transdisciplinary research to achieve truly transformative advances that can engross researchers, funders, legislators, and the general public alike. Progress is being made to achieve this goal in evolutionary biology, where methods and insights from biology, mathematics, physics, chemistry, and computational science have already become tightly intertwined. Social sciences are moving in a similar direction. This trend is especially visible in the establishment of several "synthesis centers" by the NSF in the last couple of decades. Each center has been a tremendous success (15). Besides advancing research, these centers have nurtured a cadre of early career life- and social scientists trained in transdisciplinary research.

Making further progress will require further investment. With opportunity in sight and tools in hand, strategic injections of support from funding agencies like the NSF will be necessary to build momentum towards deriving a unified theory of human origins and social and cultural evolution.

In 1871 Darwin made a good start on a synthetic theory of human biological and cultural evolution. However in the late 19th and early 20 centuries, many of his most notable synthetic ideas were lost as the social and life sciences became separate disciplines. With Darwin's work serving as a touchstone, the emerging synthesis pictures biology and culture as intricately entwined. Thus, what was old is once again new - an understanding worth celebrating for its own sake and for what it may inspire.

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