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THE CHALLENGE OF THE ORIGINS OF MODERN HUMANS

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In their recently published essay Kintigh et al. mention the problem of the origins of modern humans amongst the grand challenges of archaeology, and this challenge is shared with numerous other disciplines.[2] The question of "where do we come from" has an unmistakable importance in European thinking, and the beginnings of scientific research into this essentially stretch back to the birth of the scientific method. The last word in this effort is represented by the "grand challenge", which demands the creation of an effective form of collaboration between the branches of science within the environment of the technology and communication that is developing at an unprecedented rate in our information-based society.

1. THE GRAND CHALLENGE

The phrase *the grand challenge* appears in one of the research reports of the government of the United States of America from 1987:

"A **grand challenge** is a fundamental problem in science or engineering, with broad applications, whose solution would be enabled by the application of the high performance computing resources that could become available in the near future."[3]

In recent years the concept has been defined in many ways (*Table 1*), but its strength is precisely represented in its clear and sensible formulation: a task that tests people and whose completion will be of great use. The reason for the scientific success of the grand challenge is that the research communities will be shaped by goals that are clearly defined and are placed at the frontiers of the group's abilities.

The modern tools of communication do not only ensure the formation of these communities, but also make their close collaboration unavoidable. Digital technologies make possible the storage and sharing of essentially unlimited amounts of data, which is a crucial difference with scientific dialogue based on printed publications. Through the World Wide Web, society is in a virtual condition of a "constant conference". More and more researchers, institutions, publishers and the social sphere consider scientific activity to be a system of multiple actors working together.[4]

The vast amount of information cannot be comprehended by the individual, a new Binford, Breuil or Childe can no longer emerge from the enormity of opinions and data in the 21st century.[5] The grand challenges can play a guiding role, replacing the "great men" of archaeology and synchronizing the detailed work of experts active in the various fields.

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[2] Kintigh, Keith. W. et al.: Grand challenges for archaeology. *Proceedings of the National Academy of Sciences of the United States of America* 111 (2014)/3, 879–880.

[3] Executive Office of the President Office of Science and Technology Policy: *A research and development strategy for high performance computing* (1987), 3.

[4] For example, see: Destro Bisol, Giovanni et al.: Perspectives on open science and scientific data sharing: an interdisciplinary workshop. *Rivista di antropologia* 92 (2014), 179–200. Fecher, Benedict – Friesike, Sacha: Open Science: One Term, Five Schools of Thought. In: *Opening Science. The Evolving Guide on How the Internet is Changing Research, Collaboration and Scholarly Publishing*, ed. Bartling, Sönke – Friesike, Sacha, 17–47. (Springer Open, 2014); Kansa, Eric C. et al: Publishing and Pushing: Mixing Models for Communicating Research Data in Archaeology. *International Journal of Digital Curation* 9 (2014)/1, 57–70.

[5] Lewis Binford (1931–2011), Henri Breuil (1877–1961) and Gordon Childe (1892–1957) were key individuals in the history of the science of archaeology.

Table 1. *Characteristics of scientific grand challenges, according to different authors. Sources: Arnold, David – Geser, Guntram: EPOCH Research Agenda for the Applications of ICT to Cultural Heritage: full report. Budapest: Archaeolingua, 2008; Hoare, Tony: The verifying compiler: a grand challenge for computing research. Journal of the Advancing Computing as a Science & Profession 50 (2003)/1, 63–69; Huggett, Jeremy: Challenging Digital Archaeology. Open Archaeology 1 (2015), 79–85; Kalil, Tom: The Grand Challenges of the 21st Century. Prepared Remarks at the Information Technology and Innovation Foundation. Washington DC, 2012; Kilbride, William: Grand challenges: grand opportunities? Archaeology, the historic environment sector and the e-science programme. In: AHDS e-Science Scoping Study Expert Seminar Report. Glasgow, 2006; McGettrick, Andrew et al.: Grand Challenges in Computing: Education – A Summary. The Computer Journal 48 (2005)/1, 42–48.*

Kalil	Hoare	Arnold–Geser	Kilbride	McGettick et al.
Has a serious impact on the scientific field	Leads to a change in perspective			Significant development
Ambitious, but achievable	Ambition for truly innovative action			
Inner compulsion and motivation for completion	Enthusiastic support even outside the narrow scientific community	Brings together representatives of various scientific fields and also speaks to the general public	Brings in and includes in itself the entire community	Raises curiosity in the general public; is unambiguous and seizes the imagination
Is in the middle path between special professional problems and general questions	Can be broken down into secondary objectives, which can be completed even if the grand challenge cannot be		International, multi-scaled, sustainable and inclusive; failure of the challenge is not the failure of the project	Has a message of international scale as well
Includes great discoveries and innovative methods and developments	Goes beyond the limits of initial possibilities, creates unknown techniques, tools and results	Includes technological innovations, not the modification of existing techniques. Does not just borrow technology from other fields	The fundamental research pushes the limits of the use of information technologies	Can be the cause for an alteration of opinions and expectations, or even social change
		Has a role in the preservation of cultural heritage	Follows the demands of archaeology, does not depend on the possibilities from borrowed technologies	

2. THE ORIGINS OF MODERN HUMANS AND THE UPPER PALAEOLITHIC IN EUROPE

"What are the biophysical, sociocultural and environmental interactions out of which modern human behavior emerged?" [6] Three types of sources appear in this challenge: material cultural remains in prehistoric (palaeolithic) archaeology, human remains in palaeoanthropology and palaeogenetics and the environment in palaeoecology and its related fields.

But what does modern human behavior mean, how can we examine its traces and where do we look for its origins? The sources are varied and provide answers in different ways. Geneticists map out the molecular traces in humans living today and in fossil bones, while palaeoanthropologists study the bodily structure of our ancestors. For us, we are modern humans, and our behavior is the standard.

[6] Kintigh, Keith. W. et al.: *Grand challenges for archaeology. Proceedings of the National Academy of Sciences of the United States of America* 111 (2014)/3, 880.

Archaeologists are less sure in their tasks if the topic is modern *behavior* similar to that of today, since they examine its direct evidence, the material culture of the past. "Modern" is here to be understood in the scale of human evolution, and the European *Homo sapiens* are contrasted with earlier human ancestors. Was it only our species that was able to shape the environment in a complex manner and communicate effectively with its compatriots? Or are these abilities much older? Objects shaped by human hands accompany the history of the *Homo* genus for nearly three million years – the great majority in the form of stone tools that are essentially identical to the eyes of a non-expert. In the research into the evolution of modern behavior these stones and their sites stand as faint traces for archaeology.

In terms of "where", there is strong evidence that the ancestors of the humans *living today* appeared in Eastern Africa about two hundred thousand years ago.[7] Despite this, the debate about origins had been centered around Europe up to the turn of the millennium, to a great extent due to the research history.[8] According to our current knowledge *Homo sapiens* arrived on our continent from the direction of the Middle East, only about forty-five thousand years ago.[9] The earliest human bone remains came to light in Romania and are about forty thousand years old.[10]

Likewise, at this time, the beginning of the Upper Palaeolithic, new stone tool industries appeared in Europe, which we have placed under the comprehensive designation of the Aurignacien technocomplex (*Fig. 1*). The stone tools from the period preceding this were made by Neanderthal people (*Homo neanderthalensis*), while the Aurignacien finds were in all likelihood left behind by modern humans.[11] Therefore, the opinion developed in the first half of the 20th century that if there can be prehistoric evidence suggesting the behavior of modern humans, then it may look like the European relics of *Homo sapiens*. The list of these archaeological traces is in essence a selection of the elements of the material culture of the (western) European Upper Palaeolithic, which were unknown for a long time in other parts of the world (*Table 2*).

This archaeological model has come under serious fire from critics in the last fifteen years. The set of elements that are considered archeological traces of modern behavior have been shown at sites in Africa and Eurasia that are older than forty thousand years in connection with both *sapiens* and *neaderthalensis*.[12] The most recent genetic research has also shed light on the fact that the *Homo sapiens* migrating out of Africa intermixed with the Neanderthals. The residents of Eurasia, including you, the reader, have Neanderthal genes as well.[13]

So, in 2016 it is more and more difficult to categorize the data on our ancestors in history within the framework of the "modern = European *sapiens*/primitive = everyone else" dichotomy, and the drafting of a new script is proceeding slowly. We do not know precisely what relationship the observed variety in the archaeological find materials has with the diversity of the fossilized human remains and the information supplied by palaeogenetics on the evolution and migrations of groups of prehistoric humans. In the widest sense the opinions can be divided into three groups.

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7 McDougall, Ian – Brown, Francis H. – Fleagle, John G.: Stratigraphic placement and age of modern humans from Kibish, Ethiopia. *Nature* 433 (2005), 733–736. Rito, Teresa et al.: The First Modern Human Dispersals across Africa. *PLoS ONE* 8 (2013)/11, e80031.

8 Here we can only hint at the library's worth of literature, which analyses the reasons and results of this. See the abundant bibliographies of the books listed in the recommended literature.

9 Pagani, Luca et al.: Tracing the Route of Modern Humans out of Africa by Using 225 Human Genome Sequences from Ethiopians and Egyptians. *The American Journal of Human Genetics* 96 (2015), 986–991.

10 Fu, Qiaomey et al.: An early modern human from Romania with a recent Neanderthal ancestor. *Nature* 524 (2015), 216–220.

11 Benazzi, Stefano et al.: The makers of the Protoaurignacian and implications for Neandertal extinction. *Science* 348 (2015), 793–796.

12 Ld. pl. McBrearty, Sally – Brooks, Alison S.: The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39 (2000), 453–563. Villa, Paola – Roebroeks, Wil: Neandertal Demise: An Archaeological Analysis of the Modern Human Superiority Complex. *PLoS ONE* 9 (2014)/4, e96424.

13 See, for example: Sánchez-Quinto, Federico – Lalueza-Fox, Carles: Almost 20 years of Neanderthal palaeogenetics: adaptation, admixture, diversity, demography and extinction. *Philosophical Transactions of the Royal Society Biological Sciences* 370 (2015), 20130374.

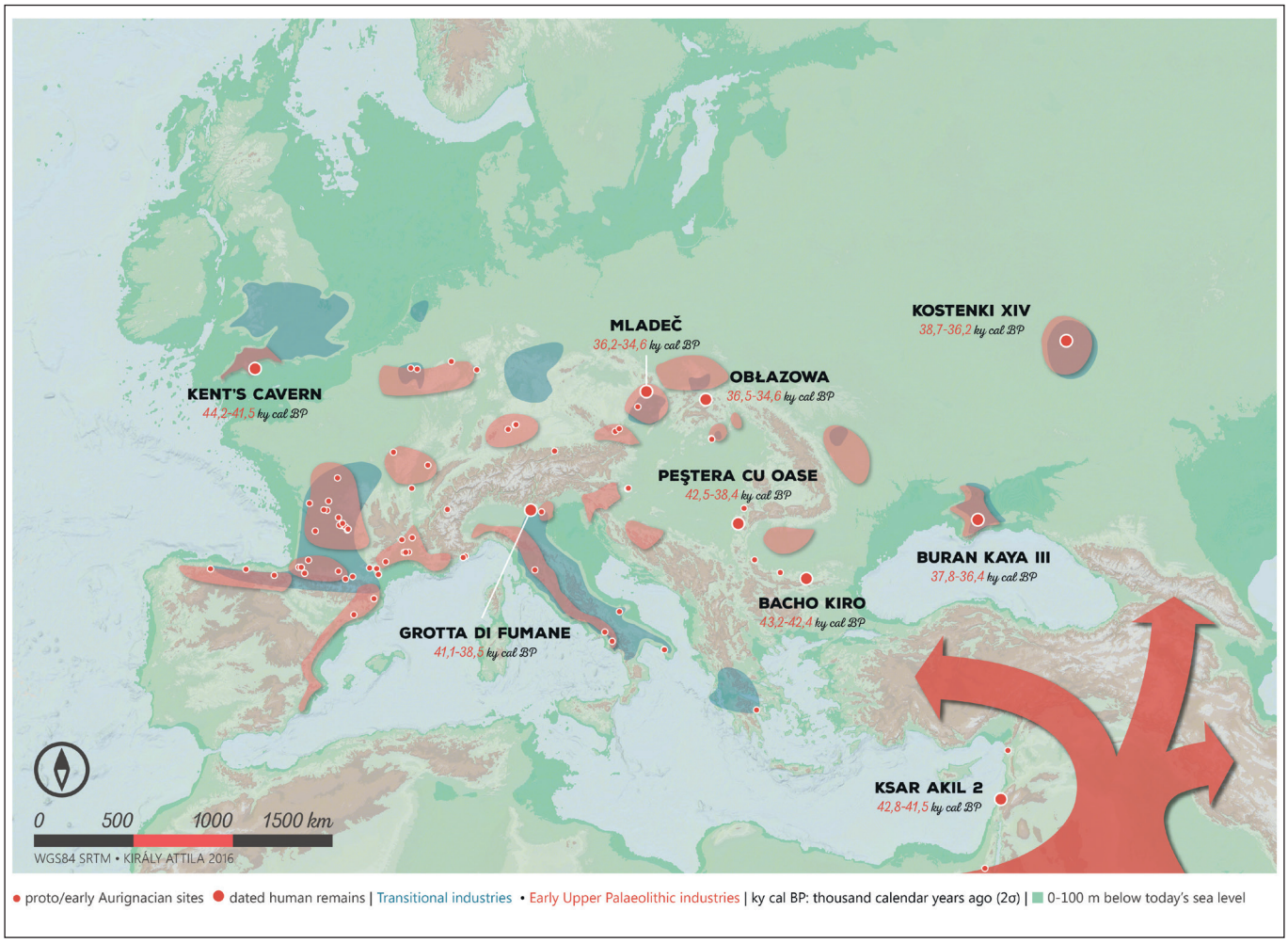

Figure 1. *Lithic industries and Homo sapiens remain in Europe, 45-35 ka BP. During the last glaciation coastline of our continent was different, there were more land for habitation. At the beginning of the marked period, Neanderthal-made Middle Palaeolithic industries are almost omnipresent, those are not marked on the map. Blue marks the so-called Transitional Industries: assemblage with both Middle and Upper Palaeolithic characteristics. Most of these were found without human remains, hence we do not know their makers. Red arrows point to the initial dispersal of modern humans to Eurasia. Red denotes the main early Aurignacian habitation areas, red dots implicate the most important early modern archaeological sites. The earliest Homo sapiens fossils are found at the named sites on the map. Age ranges for these fossils are given by two dates at each site. Exact age is somewhere between these two values, with 95% confidence. Map and data: Attila Király. doi: 10.6084/m9.figshare.2430055*

1) In the *evolutionary phases* approach there are long, uneventful periods of human evolution and progress is made in jumps of rapid change.[14] According to this logic, modern cognitive abilities[15] and the other "biological" problem solving characteristics developed suddenly, because the environmental challenges required immediate responses. The *Homo sapiens* that arrived in Europe developed a set of new behaviors in a relatively short time in the new environment, which may have been spurred by some kind of genetic change.

[14] See, for example: Klein, Richard G.: Archeology and the Evolution of Human Behavior. *Evolutionary Anthropology* 9 (2000)/1, 17–36. Mellars, Paul A.: The impossible coincidence. A single-species model for the origins of modern human behavior in Europe. *Evolutionary Anthropology* 14 (2005)/1, 12–27.

[15] Modern cognitive abilities: taken in the wider sense, thought characteristic of present-day humans. People are able to create an abstract representation of the world without the imagined occurrence actually happening. These can be shared with others, and naturally they are able to understand the representations of others. This ability to design and show empathy is a unique characteristic of humans, although we do not know whether within the *Homo* genus this is exclusively characteristic of only us, modern *Homo sapiens*.

Table 2. *Traditional views about archaeological signatures of modern human behavior, according to McBrearty-Brooks 2000*

Ecology
Settlement of previously uninhabited areas (tropical rainforests, islands, periglacial areas)
Expansion of the dietary base (varied diet)
Technology
New stone working technologies: blades, microblades and blunting
Increasing standardization within the formal categories of implements
Tools with handles and complex (inset) tools
Use of new raw materials in the manufacturing of implements (bone, antler, etc.)
Manufacturing of task-specific implements (e.g. spear and arrow heads, geometric microliths)
Range of implements with a varied composition
Geographical variation in the formal categories of implements
Variation over time in the formal categories of implements
Wide-ranging and specialized use of fire
Economy and Society
Acquisition of raw stone materials from far away and trade in raw materials
Strategic use of raw stone materials from far away (curation)
Hunting of large and dangerous animals
Seasonal planning for the acquisition of resources
Return to abandoned camps (permanent camp sites)
Increasing intensity of the acquisition of resources and the utilization of aquatic resources
Long-distance trade relationships
Self-identity and group identity appear in the fashioning of objects
Organized use of camp sites (special activity areas within the camps)
Use of Symbols
Regional styles of objects
Self-decoration, e.g. beads and other jewelry
Use of pigments
Use of engraved and scored objects (bone, eggshell, lumps of ochre, stone)
Figurative representation (paintings, engravings, sculpture)
Conscious burial with grave goods and the traces of pigments and ritual activity

2) According to the *gradual evolution* approach revolutionary changes such as this did not occur.[16] The local natural circumstances continuously mold human behavior, and the tiny changes accumulate over hundreds of generations. The greatest evolutionary advantage of modern humans is not some set genetic characteristic, but instead flexibility. Due to this it may be that the archaeological profile of Europe is a mosaic; amongst the environmental conditions that change from region to region humans "evolved" diverse strategies for adaptation.

3) According to the third group of thought, these theories devote little attention to the fact that humans are one another's most significant environmental elements.[17] Humans are able to share complex cultural messages with their compatriots. The *cultural traditions* that transmit the knowledge of the group are efficient solutions that are not just a slow adaptation to the environment, but instead make the transformation of the environment possible. Thus, the stone industries of the Upper Palaeolithic reflect the impact of environmental and cultural influences on one another at the same time, whose mutual history unfolded in various ways in the different areas of Europe (*Fig. 2*).

3. THE CHALLENGE OF THE ORIGINS OF MODERN HUMANS

According to many researchers our current knowledge is too limited to be able to construct models such as those above to explain the origins of modern humans.[18] The problem is extraordinarily complex, and the chance that finds have survived for such a long time is quite small. Modern excavation and examination methods are therefore extremely meticulous and provide an immense amount of data, which makes framing them in a synthesis on a European scale quite difficult. However, to properly interpret local phenomena this synthesis is necessary.[19] The way of life before the development of an agricultural economy was fundamentally nomadic, following the natural distribution of resources. Therefore, the history of *Homo sapiens* in Europe is closely related to the seasonal migrations and larger movements of peoples, which connect sites that are distant from one another. In the following, I will present a few projects from the last couple of years that tackle the "grand challenge", highlighting the need for a synthesis.

To link the diversity observed in stone industries to climatic or biological changes or to migrations, we must know whether these events even happened at the same time. In relation to the ten thousand year period representing the transition from the Middle to the Upper Palaeolithic, radiometric dating methods[20] either do not work or are not sufficiently precise. Therefore, stratigraphy, the relative position of the soil layers that make up a site, plays an important role in dating. However, these series of layers develop in an entirely different manner whether the site is in a cave or on the open surface, or whether it is in Germany or Hungary.

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[16] Ld. pl. Richerson, Peter J. – Boyd, Robert – Bettinger, Robert L.: Cultural innovations and demographic change. *Human Biology* 81 (2009)/2–3, 211–235; Shea, John J.: *Homo sapiens* Is as *Homo sapiens* Was. Behavioral Variability versus "Behavioral modernity" in Paleolithic Archaeology. *Current Anthropology* 52 (2011)/1, 1–35.

[17] See, for example: Gamble, Clive – Gowlett, John – Dunbar, Robin: The Social Brain and the Shape of the Palaeolithic. *Cambridge Archaeological Journal* 21 (2011)/1, 115–135; Mesoudi, Alex: Cultural Evolution: A Review of Theory, Findings and Controversies. *Evolutionary Biology* (2015), doi: 10.1007/s11692-015-9320-0. Lycett, Stephen J.: Cultural evolutionary approaches to artifact variation over time and space: basis, progress, and prospects. *Journal of Archaeological Science* 56 (2015), 21–31.

[18] See, for example the notes and citations in Harrold. Harrold, Francis B.: Historical Perspectives on the European Transition from Middle to Upper Paleolithic. In: *Sourcebook of Paleolithic Transitions. Methods, Theories, and Interpretations*, ed. Camps, Marta – Chauhan, Parth, 292–293. (New York: Springer, 2009)

[19] E.g. Kuhn, Steven L.: Questions of Complexity and Scale in Explanations for Cultural Transitions in the Pleistocene: A Case Study from the Early Upper Paleolithic. *Journal of Archaeological Method and Theory* 20 (2013)/ 2, 194–211.

[20] Here we mean all dating procedures that are based upon the measurement of the radioactive decay of some element. Of these, the best known and most commonly utilized method is radiocarbon (otherwise known as C-14) dating.

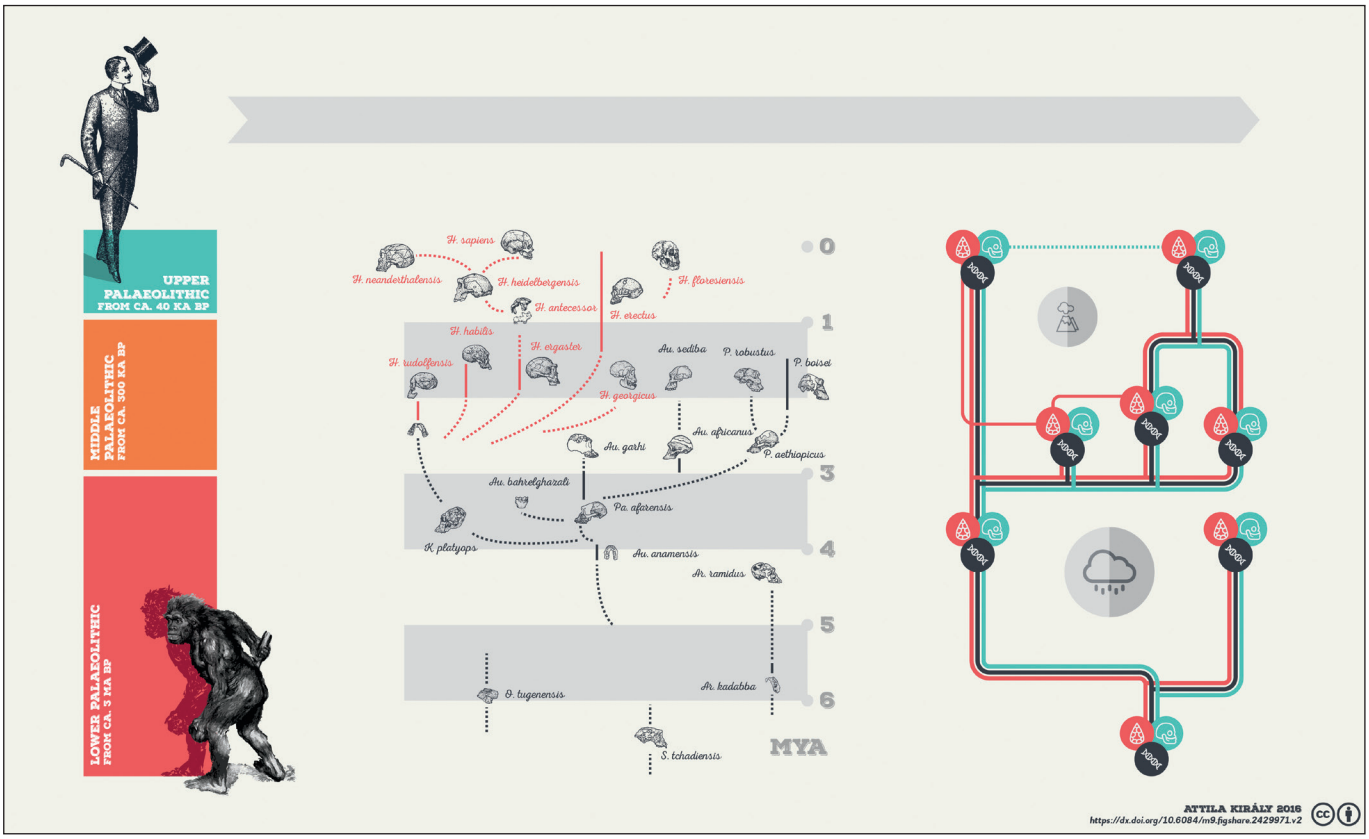

Figure 2. *Models of modern human origins. Left – totempole model. Human evolution was seen as an unidirectional progress from primitive to civilized in the first half of the 20. century. Tripartite division of the Palaeolithic age complied under this biased impression. Middle – tree of life model. Our phylogenesis seen as a branching tree, as the Homo genus radiated and isolated around the world. Relationships among species is obscured by the shortness of palaeoanthropological data. Right – tendril model. In the real world not species but populations became the units of selection, across space and time. The human groups carry their genetic heritage (black), their phenotype (green) and their cultural traditions (red). Ecological and climatic factors, together with the mentioned biological-cultural traits were and are interwoven in a tendril-like story. The researchers uncover remnants of these tendrils in the field. The Grand Challenge today is not to reduce these complex interrelations to unicausal models, but to model the complexity, with the help of modern digital technologies at hand.*
Data and figure: Attila Király. doi: 10.6084/m9.figshare.2429971

The RESET (Response of humans to abrupt Environmental Transitions) project that took place between 2008 and 2013 found an elegant solution for comparing distant sets of strata.[21] A few prehistoric volcanic eruptions were so powerful in Europe that the winds spread the ash from them over several thousands of square kilometers. The volcanic ash layers that were created in this manner were deposited at essentially the same time over the affected areas. The 146 stratigraphic samples examined within the context of the RESET project identified the chronological links amongst numerous sites throughout Europe. The samples taken from the Szeleta Cave in Hungary contributed to the success of the project.[22]

The objective of the "Our Road to Europe" undertaking is to use every available means to trace the route of our ancestors from Eastern Africa to Central Europe.[23] The project is performing an entire array of archaeological excavations and scientific investigations starting from Ethiopia, through Egypt, the Middle East, the Balkans and the Carpathian Basin, all the way to Germany. Through this it will be possible to

[21] Lowe, John J. et al.: The RESET project: constructing a European tephra lattice for refined synchronisation of environmental and archaeological events during the last c. 100 ka. *Quaternary Science Reviews* 118 (2015), 1–17.
[22] Lowe, John J. et al.: The RESET project: constructing a European tephra lattice for refi ned synchronisation of environmental and archaeological events during the last c. 100 ka. *Quaternary Science Reviews* 118 (2015), 13.
[23] http://www.sfb806.uni-koeln.de/ Date of access: 10 January 2016

scrutinize the diverse theories related to the origins of modern humans in practice and in the field. Within the context of the project, probing excavations were performed in the Fall of 2015 in collaboration with Hungarian experts.[24] A comprehensive research program such as this is an outstanding opportunity to mobilize European experts, which the web site of the undertaking also shows. Reports from meetings and conferences, job offers, scholarships opportunities and blogs appear on this digital forum. One of the most important elements is the institutional repository, through which those participating in the work are able to share their research data with those interested.

In recent decades many institutions and undertakings have provided similar data sharing services, which provide the opportunity for a European scale synthesis that has not been possible before. Exemplifying this opportunity is the database of the Katholieke Universiteit Leuven, which contains 12,968 dated samples from Palaeolithic sites in Europe and is freely accessible.[25] An internet database operated on similar principles is NESPOS, which concentrates on the Pleistocene epoch and stores 3D scans of bones and archaeological finds, photographs, publications and other research data.[26] The essential element of these services is their digital format, which makes them available to be used in, modify and correct the work of others. Imagine how much time it would take to find out how old the European Aurignacien sites are on average without the sharing of digital data. It would be necessary to scour through entire libraries to find the scattered chronological data in articles and excavation reports, which then would need to be collated in a table just so it would be possible to calculate an average. The creators of the database in Leuven have already done this work; it only takes the press of a button and we get the much desired average. With the aid of digital databases experts can see one another's partial results even during field work, making planning easier, collaboration more effective and research more productive.

4. FINAL THOUGHTS

"What are the biophysical, sociocultural and environmental interactions out of which modern human behavior emerged?" Instead of the nature of modern human behavior, the grand challenge examines all of the concrete factors that have been shaped through human history in the last two hundred thousand years. Until these factors are identified, we will be unable to define the concept of "modern".

In the scholarly dialogue about our origins up until now the complex reality has been simplified with the aid of the models. In the words of Lawrence Guy Straus, today entirely different scientific demands have developed, and in our models we wish to stick to the complex reality.[27] The most recent digital technologies provide us with this opportunity; the smooth synchronization of the detailed work of hundreds of researchers is an undoubtedly difficult but attainable undertaking. The research into the origins of modern humans in the 21st century stands before the challenge of the diversity of the data and opinions.

[24] Zandler, Krisztián – Király, Attila: *Előzetes jelentés Szécsénke-Kis-Ferenc-hegy Szeletien lelőhely 2015. évi szondázó ásatásáról* (Preliminary Report on the Probing Excavations of 2015 at the Szécsénke-Kis-Ferenc-hegy Szeletien Site). Előadás a 6. Kőkor Kerekasztalon (Presentation at the 6th Stone Age Round Table). 11 December 2015. Miskolc, Herman Ottó Museum, Pannon-tenger Museum. doi: 10.6084/m9.figshare.2304688

[25] Vermeersch, Pierre M.: Radiocarbon Palaeolithic Europe Database, Version 18 (2015).

[26] https://www.nespos.org Date of access: 10 January 2016

[27] Straus, Lawrence G.: Has the Notion of "Transitions" in Paleolithic Prehistory Outlived Its Usefulness? The European Record in Wider Context. In: Camps, Marta – Chauhan, Parth (eds.) *Sourcebook of Paleolithic Transitions. Methods, Theories, and Interpretations*, 3–18. (New York: Springer, 2009)

RECOMMENDED LITERATURE

OPEN SCIENCE AND GRAND CHALLENGES

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THE ORIGINS OF MODERN HUMAN BEHAVIOR AND EUROPEAN ARCHAEOLOGY, PROFESSIONAL LITERATURE

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Masters of the Planet: The Search for Our Human Origins. New York: Palgrave Macmillan, 2012.