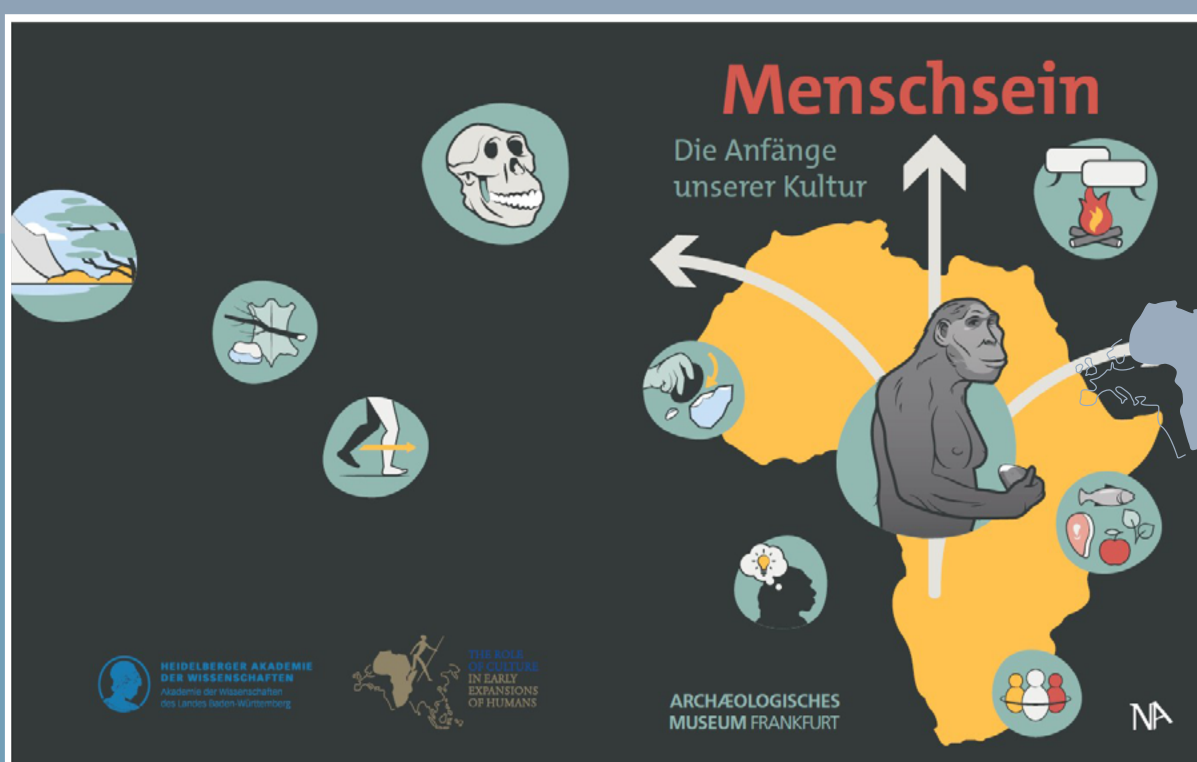
newsletter 18 | 2021

# The Role of Culture in Early Expansions of Humans (ROCEEH)




*Cover of the book which accompanies the exhibition "Being Human // The Origins of Our Culture" in Frankfurt, Germany. Graphics: B. Groscurth.*

HEIDELBERGER AKADEMIE DER WISSENSCHAFTEN
Akademie der Wissenschaften des Landes Baden-Württemberg

THE ROLE OF CULTURE IN EARLY EXPANSIONS OF HUMANS

# Editorial

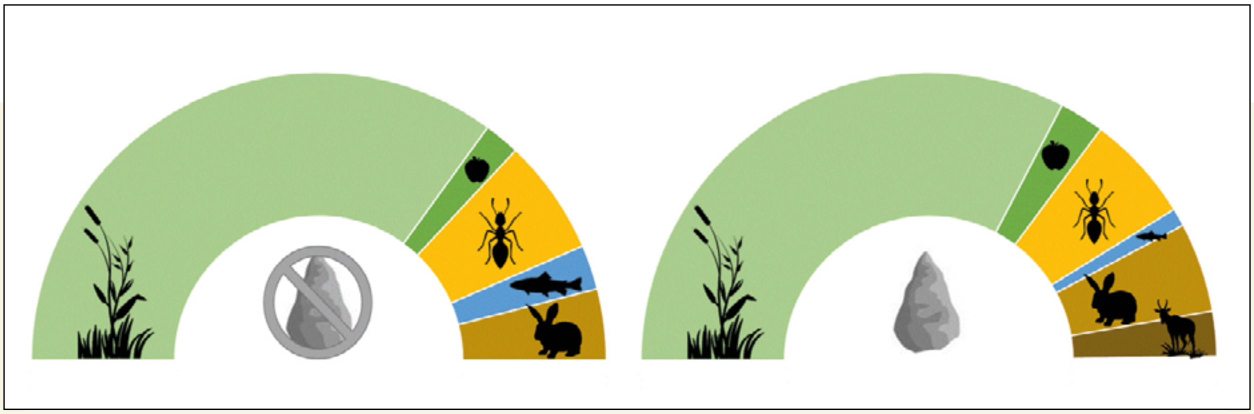
The 18th newsletter focuses on the diet of *Paranthropus boisei* and how environmental conditions and technical capabilities affected it. We report on ROCEEH's collaboration with ARIADNEplus, a large-scale European project on the scientific infrastructure of archaeological data. We also announce the opening of the exhibition "Being Human // The Origins of Our Culture" at the Archäologisches Museum Frankfurt. Finally, we review the content and outcome of ROCEEH's first online conference "Human Origins – Digital Future", held in July, 2020.

## What was on the menu of *Paranthropus boisei*?

The dispersal of early hominids out of Africa is a central issue of the ROCEEH research center and can be studied from different perspectives. One of these is the diet composition model, which applies an ecological approach to understand range expansion, examining the link between environment, technology and diet. The diet of a hominid represents a selection of available resources in the environment. But not all resources are accessible to every kind of hominid. Which resources can be extracted depends on amenable skills, behavioral performances, tools, and collaboration. Hunting, for instance, requires sophisticated equipment such as spears, sticks, and elaborate social cooperation. Many plant parts are toxic, or at least not digestible unless they are cooked. Hominids select their resources from the seasonally changing resource space, which he or she manages, and which covers basic needs for calories and nutrients. Thus, a hominid individual's selection of food is reflected by dietary signals such as stable isotopes in teeth and bones, or molar microwear, because resources vary in their chemical and mechanical properties. By combining data about skills and capabilities of particular hominids on the one hand, and about resources in the environment on the other, we can infer the composition of the consumed diet.

Let's take a look at the diet of *Paranthropus boisei* (Fig. 1). Mary and Louis Leakey discovered the type specimen OH5 in Middle Bed I, level 22 (FLK Zinj) at Olduvai Gorge, Tanzania. What do we know about the environment of 'Zinj' (*Zinjanthropus boisei*, later renamed *Paranthropus boisei*), the potential spectrum of resources, the tools he or she might have used, and his or her behavioral skills? The site was located on the eastern margin of the saline-alkaline paleo-lake Olduvai. About 1.8 million years ago, the landscape along the banks of Lake Olduvai was diverse: patches of dense woody vegetation with scattered palms were situated in a grass-dominated biome similar to a wooded

▲ Figure 1. Skull of *Paranthropus boisei*, OH 5.
Photo: Nicolas Guerin, CC BY-SA 3.0.



▲ Figure 2. The average diet composition of *P. boisei* with basic technology (case 1, left) and Oldowan technology (case 2, right). Graphics: S. Krüger.

grassland. The large mammalian fauna consisted mainly of bovids, but also included pigs, horses, giraffes and primates. The small mammalian fauna included different kinds of rodents, hare, shrews and bats. There are also fossil remains of crocodiles, turtles, snakes, amphibians, birds, fish, and molluscs. In other words, *Paranthropus*' table abounded with resources, which we assign to five groups that provide different nutrients and require variable skills: plants, insects, and aquatic animals as well as small and large terrestrial animals.

Whether *Paranthropus* used Oldowan stone tools is still disputed, so we consider two scenarios. Oldowan technology includes stone tools with cutting edges flaked by percussion. These stone tools could be used to butcher animals and produce more efficient implements such as digging sticks or spears. Even if *P. boisei* did not use stone tools, they would have likely employed a basic form of tool behaviour similar to great apes, one which leaves only faint traces in the archaeological record, or none at all. Thus the first case assumes *P. boisei* used basic technology, while the second case assumes they had access to modular technology such as the Oldowan stone tools found within the same layer. The different levels of technology set the maximal exploitation rate of the resource groups.

The contributions of each of the categories of food can now be calculated. A potential diet must cover the daily nutritional requirements as defined by the organism and also match the dietary signals collected from the fossil specimen. The nutritional requirements are based on an average male body weight of 49 kg (for OH5) corresponding to 9110 kJ, 32 g protein, and 49 g fat per day. The analysed molar of OH5 has a $\delta^{13}C$ value of -1.2‰. The model provides all potential diet compositions that match both the given nutritional requirements and the $\delta^{13}C$ signal within a range of 0.5‰.

For case 1 with only basic technology, 11 potential diet compositions remain. The average contribution from plants and plant parts is 74%, represented primarily by C4-plants in this particular environment. Insects contribute 13% on average, aquatic animals around 5% and small terrestrial animals only 8% (Figure 2). Large mammals are irrelevant as a regular food source. However, for case 2 with modular technology, the diet becomes vastly more diverse: 55 potential diet compositions remain. The average contribution from plants and plant parts is slightly lower (70%), particularly in favor of small (10%) and large animals (5%). The contribution of insects stays in a similar range, and aquatic animals drop from an already low level (Fig. 2).

The lion's share of *Paranthropus*' dinner plate consisted of C4 plants, for instance sedges, with edible underground storage organs, leaves and seeds. Insects comprise a minor but constant food component and a primary source of minerals such as iron and omega-3 fatty acids. C3 plants, for instance woody plants, and aquatic animals contribute very little to the regular diet, but may provide a fallback during certain seasons. The contribution of terrestrial animals increases in accord with the technological level, and as a consequence, do does the diversity of potential compositions of the diet. The use of stone tools would have made it easier for *Paranthropus* to leave its familiar resource space and explore new food resources in different environments.

*Susanne Krüger*

**References**

Barboni, D. (2014): Vegetation of Northern Tanzania during the Plio-Pleistocene: a synthesis of the paleobotanical evidences from Laetoli, Olduvai, and Peninj hominin sites. Quaternary International 322, 264–276.

Blumenschine, R.J., Peters, C.R., Masao, F.T., Clarke, R.J., Deino, A.L., Hay, R.L., Swisher, C.C., Stanistreet, I.G., Ashley, G.M., McHenry, L.J., Sikes, N.E., van der Merwe, N.J., Tactikos, J.C., Cushing, A.E., Deocampo, D.M., Njau, J.K., Ebert, J.I. (2003): Late Pliocene *Homo* and hominid land use from western Olduvai Gorge, Tanzania. Science 299, 1217–1221.

Leakey, M.D. (1971): Olduvai Gorge, Vol. 3: Excavations in Beds I and II, 1960-1963. Cambridge University Press, Cambridge.

van der Merwe, N.J., Bamford, M.K., Masao, F.T. (2008): Isotopic evidence for contrasting diets of early hominins *Homo habilis* and *Australopithecus boisei* of Tanzania. South African Journal of Science 104, 153–155.

## ROAD & the ARIADNEplus Catalog

"The single most useful thing you can do to ensure the long-term preservation of your data is to plan for it to be re-used." (Prof. Julian Richards, Director, Archaeology Data Service, University of York, UK)

This technical article presents ROCEEH's current progress in making the ROCEEH Out of Africa Database (ROAD; https://www.roceeh.uni-tuebingen.de/roadweb/) available in accordance with principles like FAIR, which stands for "Findable, Accessible, Interoperable, Reusable." ROAD plays a central role in the ROCEEH research center, placing paleoanthropological and archaeological sites and their assemblages within a framework of paleoenvironmental data. ROAD was designed and built as a georelational database. It systematizes and catalogs primarily non-structured information from scientific publications written in many languages. For cataloging the archaeological information in ROAD, we developed thesauruses which we use internally for the project. However, from the long-term perspective of ROAD, it is desirable to maintain a database whose data are machine-readable. The data should be mappable onto standardized schemes and vocabularies in order to link them to other well-established repositories. The data should be reusable, meaning that the data licensing is clear. Finally, the documentation of the database and the presentation of its sources should be transparent.

The long-term vision for ROAD is to make it as FAIR a database as possible. Therefore, ROAD has begun to actively include the development of guidelines, workflows and best practices in accordance with the FAIR principles, as formulated by Wilkinson et al. (2016). As a case study for the development of best practice, ROCEEH started an initiative with the large-scale European project known as ARIADNEplus, which focuses especially on the archaeological domain. Since Paleolithic archaeology is currently underrepresented in ARIADNEplus, a partnership with ROAD seemed like a useful way to increase the visibility of this research area for both partners.

ARIADNEplus, as well as its predecessor ARIADNE (Archaeological Research Infrastructure for Archaeological Data Networking in Europe), is an infrastructure project of the European Union. The goal of ARIADNEplus is to support research, learning and teaching by enabling access to digital resources and advanced web services in a cloud environment. ARIADNEplus (https://portal.ariadne-infrastructure.eu/) maintains a catalog of digital datasets (metadata) which supports three types of searches: "What?" (based on a topic), "When?" (based on a temporal period) and "Where?" (based on a spatial region). ARIADNEplus provides innovative services for enhanced map-based and time period searches. The ARIADNEplus catalog is an important step in building a central place for different digital repositories situated in different countries and defined in different models and languages. The ARIADNE catalog is based on its own formal ontology (called AO or AO Cat), which details resources managed by the ARIADNEplus research infrastructure. AO is a semantic model based on the Conceptual Reference Model of the International Committee on Documentation (CIDOC CRM, for short). AO is composed of different extensions to meet the needs of data integration.

The standardization promoted by ARIADNEplus covers most archaeological domains and allows interoperability. According to Niccolucci & Richards (2019), the thematic domains of the ARIADNEplus infrastructure include (or will include):

- Human Paleobiology and Paleoenvironments
  - Paleoanthropology
  - Bioarchaeology and Ancient DNA
  - Environmental Archaeology
- Analytical Investigations
  - Inorganic Materials Study
  - Dating, including Dendrochronology
- Archaeological Prospection
  - Field Survey
  - Metal Detector Survey and archaeological finds
  - Remote sensing
- Monuments and Sites
- Inscriptions

ARIADNEplus continues to extend its existing registry by incorporating new infrastructures and improving the level of integration. It also continues to overcome ambiguities and inconsistencies in data coming from different sources by using internationally shared vocabularies and linguistic resources, such as the Getty Art and Architecture Thesaurus (AAT) and PeriodO, a gazetteer of various chronological periods. To accomplish this, they use innovative methods and tools available in the D4Science cloud. D4Science is a Hybrid Data Infrastructure facilitating data sharing and research collaboration such as Virtual Research Environments (VREs). In the VREs of D4Science, groups of geographically distributed scientists transparently and seamlessly access and process shared sets of resources (e.g., data, tools and computing capabilities).

ROCEEH's cooperation with ARIADNEplus began with a three-day workshop in Prato, Italy at the end of January, 2020. During the meeting, ARIADNE and ROCEEH agreed to the process of cooperation. Each of ARIADNE's cooperation partners prepares its own data for the ARIADNEplus aggregation pipeline and, together with the ARIADNEplus support team, processes the data in the aggregation pipeline.

For ROAD data, the process consists of four steps:

1. Define ROAD data to be aggregated according to information required by the AO Cat schema
2. Create AAT subject mappings, in which ROAD translates its vocabularies to the vocabularies of AAT
3. Define chronological entities for PeriodO
4. Create X3ML mappings for ROAD's export structure to the AO Cat schema.

The ROAD export for ARIADNEplus is a collection of assemblage resources. Each resource contains data and metadata from ROAD, including selected information about a locality and its assemblages such as category, age, material, interpretation, taxa and type of plant remains. In the export for ARIADNEplus, ROAD terms are used. To improve the findability of ROAD data in the ARIADNEplus topic search, ROAD terms are linked to the standard vocabularies used in the ARIADNEplus catalog. The ROAD support team created the matchings between ROAD vocabularies and those of Getty AAT (and its extensions). For this vocabulary matching, the ARIADNEplus project provides a tool in the D4Science cloud with which a user can quickly switch between different domains and find the best possible match for each concept. Different levels of matching exist (Exact Match, Close Match, Broad Match, Narrow Match and Related Match) which help establish the order. For the ROAD export, we performed five vocabulary matchings for category, material, interpretation, genus and plant remains. Figure 3 shows the matching record for the term "burial" in JavaScript Object Notation (JSON) format.


```
{
„sourceURI": „",
„sourceLabel": „burial",
„sourceLabelLanguage": „en",
„matchURI": „http://www.
w3.org/2004/02/skos/core#exactMatch",
„targetURI": „http://vocab.getty.edu/
aat/300263485",
„targetLabel": „burials",
„created": „2020-03-05T09:51:57.738Z",
„updated": „2020-03-18T16:18:17.418Z",
„id": 125
}
```


▲ Figure 3. The vocabulary matching for the term "burial" in JSON format. Graphics: Z. Kanaeva.

To establish chronological entities in PeriodO, we first processed the ROAD table "Archaeological Stratigraphy". This table specifies the age ranges for each cultural period and delineates their geographic extent. For example, ROAD defines the Aurignacian from 43,000-32,000 years ago in Europe and the Middle Stone Age from 300,000-30,000 years ago in Africa. After we scrubbed the data for inconsistencies, the Archaeological Data Service (https://archaeologydataservice.ac.uk/) helped


```
@prefix aocat: <https://www.ariad-
ne-infrastructure.eu/resource/ao/
cat/1.1/> .
@prefix owl:   <http://www.
w3.org/2002/07/owl#> .
@prefix rdf:   <http://www.w3.or-
g/1999/02/22-rdf-syntax-ns#> .
@prefix xml:   <http://www.w3.org/
XML/1998/namespace> .
@prefix lexvo: <http://lexvo.org/id/
iso639-2/> .
@prefix skos:  <http://www.
w3.org/2004/02/skos/core#> .
@prefix rdfs:  <http://www.
w3.org/2000/01/rdf-schema#> .
@prefix ariadneplus: <https://ariad-
ne-infrastructure.eu/aocat/> .
@prefix crmpe: <http://parthenos.d4s-
cience.org/CRMext/CRMpe/> .
@prefix crm:   <http://www.cidoc-crm.
org/cidoc-crm/> .
<https://ariadne-infrastructure.eu/
aocat/Place/E299D7CB-0F78-36CC-A7D9-
0DA2AF14047C>
        a
aocat:AO_Spatial_Region ;
        rdfs:label
„Spatial region" ;
        aocat:has_place_name  „Ethio-
pia" .
lexvo:English  a        aocat:AO_Con-
cept ;
        skos:prefLabel  „English" .
<https://ariadne-infrastructure.
eu/aocat/Agent/Project%20%22The%20
Role%20of%20Culture%20in%20Early%20
Expansions%20of%20Humans%22%20
%28ROCEEH%29>
        a
aocat:AO_Agent ;
        aocat:has_name  „Project
\"The Role of Culture in Early Expan-
sions of Humans\" (ROCEEH)" .
<https://ariadne-infrastructure.eu/
aocat/Time-Span/3320000>
        a                 aocat:AO_
Temporal_Region ;
        rdfs:label   „Temporal regi-
on" ;
        aocat:from
„3320000"^^<http://www.w3.org/2001/
XMLSchema#dateTime> ;
        aocat:un-
til  „3160000"^^<http://www.
w3.org/2001/XMLSchema#dateTime> .
…
```


▲ Figure 4. Fragment of a generated RDF document in Terse RDF Triple Language (Turtle) showing a transformed assemblage (XML to RDF) from Hadar, Ethiopia dating between 3.32 and 3.16 million years ago. Graphics: Z. Kanaeva.

transfer all 142 entries from ROAD into PeriodO. These cultural entities are now available for further mappings using any database system connected to PeriodO.

The next step was to map the ROAD export structure onto the ontology of ARIADNEplus in order to catalog the resources. Using Resource Description Framework (RDF) as a model language, AO Cat represents the structure of ARIADNEplus data. For storing data, the catalog uses the triplestore (RDF store) based on GraphDB technology to link diverse data. To conduct ontology mapping, the ARIADNEplus network provides a set of services that follows the model defined in "The SYNERGY Reference Model of Data Provision and Aggregation" (http://www.cidoc-crm.org/sites/default/files/SRM_v1.5.pdf). This set of services is called X3ML framework and is accessible in the D4Science cloud. The most important parts of the framework consist of 3M Editor and X3ML Engine. 3M Editor is a tool that allows the creation of ontology mappings. It provides guided mapping according to the logic of the deployed ontology (in our case, AO Cat) and the specification of the generation rules of the Uniform Resource Identifier (URI). X3ML Engine realizes the transformation of the source records to the target ontology. The engine takes as input the source data (currently in the form of a document in Extensible Markup Language (XML)), the description of the mappings in the X3ML definition file, and the URI generation policy file created with the 3M Editor. It then transforms the source XML document into a valid RDF document according to the X3ML definition file. Additionally, the framework provides an RDF visualization tool for quick visualization of transformed records. Figure 4 shows a fragment of a generated RDF file.

In this overview, we hope we have shown one way in which ROCEEH is making its data accessible to other researchers and the general public. This form of data sharing has its roots in the standardization of formats and technologies, which serves to reduce the complexity and heterogeneity of the research data, identify standardization options, and improve the maintainability and sustainability of the research data. By mapping attributes in ROAD onto the catalog of ARIADNEplus, we also increase the visibility of records in ROAD. This makes the data more accessible and fulfills some of the goals of FAIR. Once we complete this project, data from ROAD will be findable and accessible through ARIADNEplus, in part because they have been made interoperable through the mapping process. This will lead to the potential for their reuse in the future.

*Zara Kanaeva & Andrew W. Kandel*

**References**

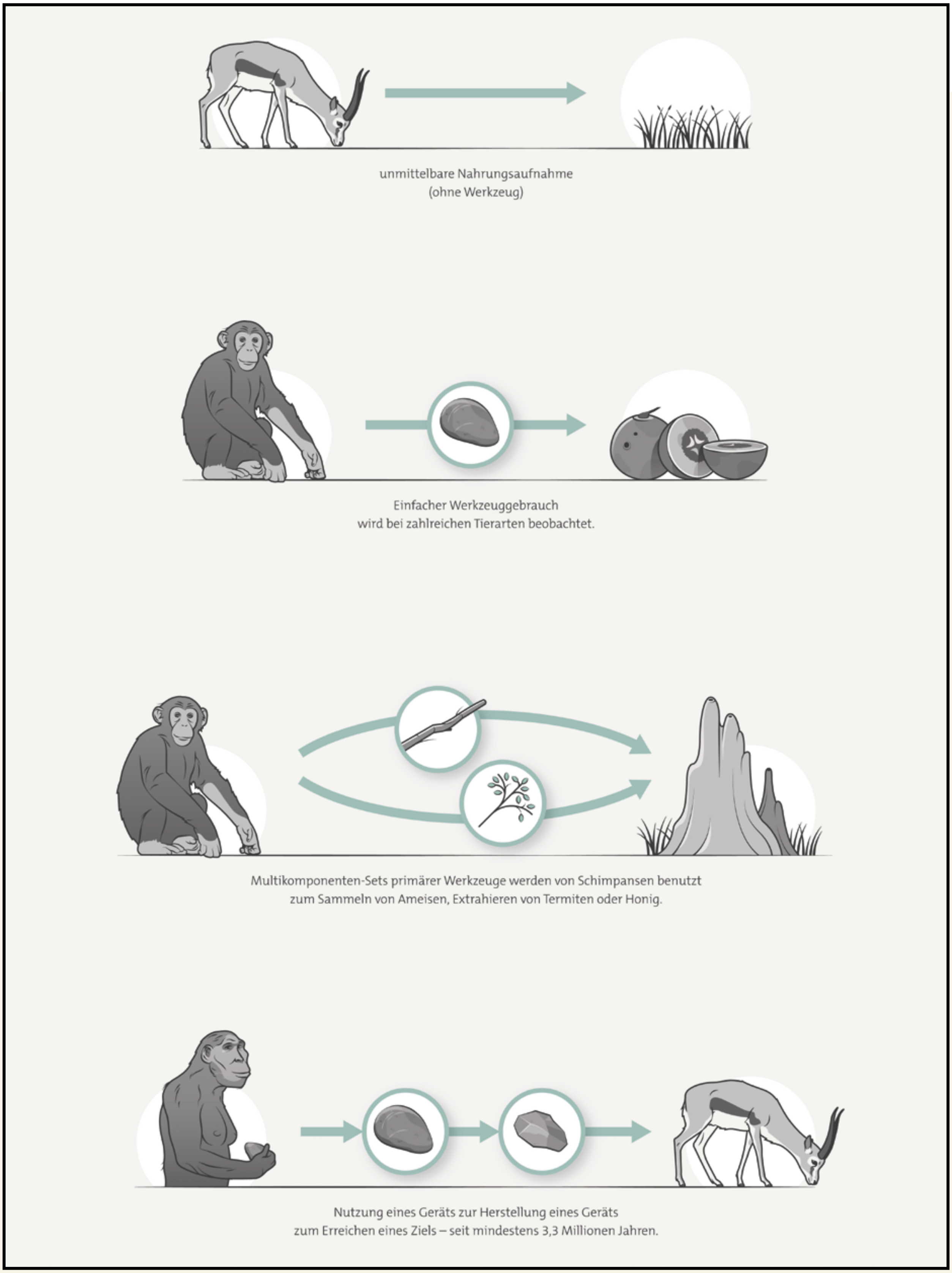
ARIADNEplus (2020): D4.1 Initial report on dataset integration, Final Version dated 8 June 2020. https://ariadne-infrastructure.eu/wp-content/uploads/2020/07/D4.1%20Initial%20report%20on%20dataset%20integration.pdf [last accessed on 15 Mar. 2021].
D4Science Hybrid Data Infrastructure facilitating data sharing and research collaborations. http://aims.fao.org/activity/blog/d4science-hybrid-data-infrastructure-facilitating-data-sharing-and-research [last accessed on 1 Mar. 2021].
Niccolucci, F., Richards, J., (eds.) (2019): The ARIADNE Impact. Archaeolingua, Budapest. https://zenodo.org/record/3476712#.YFn0EucxlhF [last accessed on 1 Mar. 2021].
Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M., Baak, A., Mons, B. (2016): The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data 3, 160018. DOI:10.1038/sdata.2016.18

## Being Human // The Origins of Our Culture An exhibition at the Archeology Museum Frankfurt in cooperation with ROCEEH

5 May 2021 – 30 January 2022

What are the foundations of our culture? Where and when can we find evidence of the origins of being human? What were the first steps on our way to becoming human? To approach these central questions about human evolution, the exhibition highlights the earliest phase of the development of our genus *Homo* between 3.3 and 1 million years ago in Africa. The oldest stone tools, the earliest *Homo* fossils dating to about 2.8 million years, and the first evidence for handling fire stem from this period. Material culture unfolded starting from the production of simple flakes and advanced to the production of series of stone artifacts and handaxes, which served as multi-purpose tools. Around 2 million years ago, *Homo* started to expand into as yet unoccupied territories beyond Africa, while early hominins such as *Australopithecus* and *Paranthropus* still roamed in Eastern and Southern Africa. Starting around 1 million years ago, *Homo* became the last remaining hominin genus on earth, inhabiting vast areas in East and Southeast Asia as well as Europe.

Can 'being human' be identified on the basis of biological, social, ecological or cultural factors? Does 'being human' present itself within the body, in thoughts or through behavior? If we look at the deep history of humankind, it becomes evident how many different developments over millions of years have contributed to making us this multifaceted species that now populates the entire planet. The exhibition focuses especially on culture, its basis in social learning, evidence from chimpanzees, and early material expressions of human culture. We also address the developmental interdependencies of tool behavior, cognition, sociality and the use of resources as the long journey of human cultural evolution began. In fact, these factors still influence our practices today. Culture is not exclusive, but rather imbues everyday life. Hominins have been social beings for millions of years, creating culture while simultaneously developing through culture.




▲ Figure 5. From top to bottom: direct food intake (without tools); simple tool use as observed in several animal species; multi-component set of primary tools as used by chimpanzees to gather ants and extract termites or honey; taking a tool to produce a tool to reach a goal – secondary tool use by hominins since 3.3 million years (Graphics: B. Groscurth)

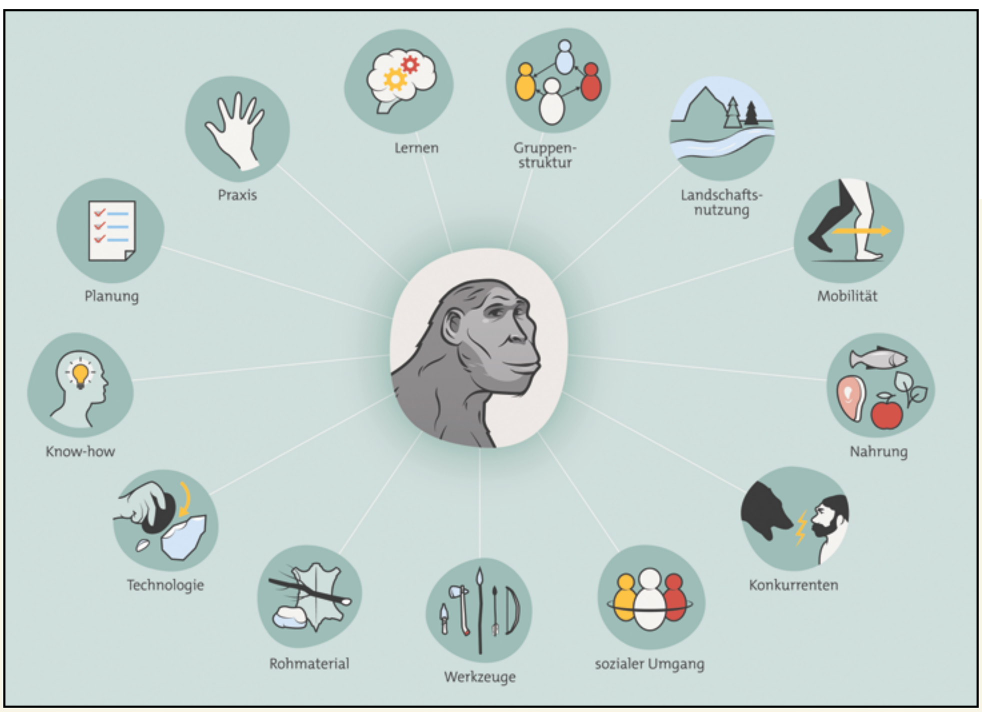
The exhibition traces some of the early key changes in tool behavior, the increasing potential for hominins to use different resources and their occupation of new ecological niches and habitats. It combines information about biological evolution, technological development, the African savanna environment, and early human dispersal out of Africa. Based on our inheritance from great apes, the first steps of human cultural unfolding are discussed and contrasted with phenomena seen as typically human, such as use of fire and language, which began to develop much later.

At the museum, tools made by chimpanzees can be compared with the earliest stone artifacts from Lomekwi dated to 3.3 million years ago as well as Oldowan tools, the earliest Out-of-Africa finds from Dmanisi (Georgia) and Acheulean handaxes. Replicas of hominin fossils can be touched and seen in their genealogical position among the large group of hominin ancestors and relatives. In addition to the presentation of objects and information in texts, graphics, films and multimedia platforms, the central focus of the exhibition lies in communication and individual experience. Six interactive stations, including an experimental box used in learning experiments, other hands-on elements and the presence of student guides, who will answer questions about the Stone Age, will allow visitors to delve deeper into the universe of their fascinating ancestors.

An abundantly illustrated volume with 13 chapters will accompany the exhibition, and a lecture series is planned. This exhibition represents the first synthesis of ROCEEH's work as addressed towards a broader public audience. Concepts and ideas developed at the research center are incorporated in the exhibition, and the ROCEEH team members contributed expertise, texts, and maps.

Students of the Goethe University Frankfurt assisted in the development of the exhibition. It is supported by the Kulturfonds Frankfurt RheinMain, the Stiftung Polytechnische Gesellschaft Frankfurt am Main and the Historisch-Archäologische Gesellschaft Frankfurt.

*Miriam N. Haidle*

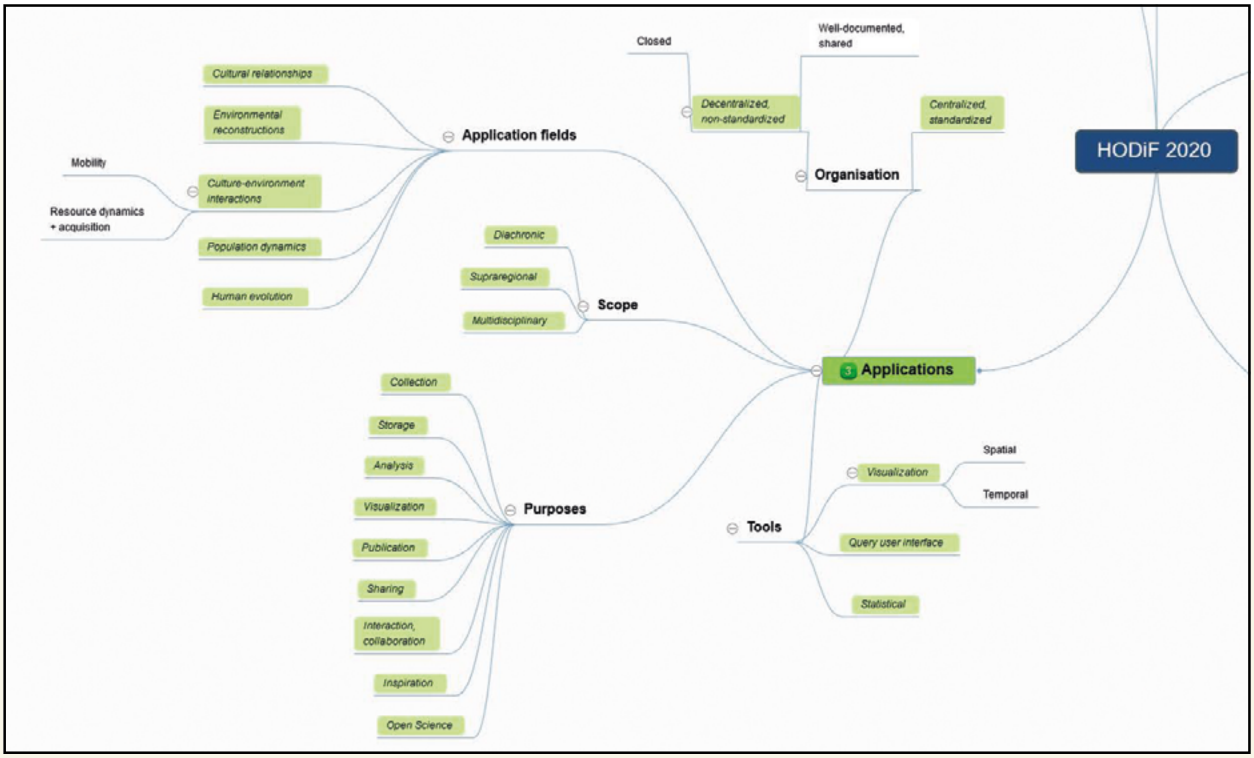



▲ Figure 6. The universe of our ancestors 2 million years ago. Clockwise, from top: learning, group structure, landscape use, mobility, food, competitors, social interaction, tools, raw material, technology, know-how, planning, practice. Graphics: B. Groscurth.

## Conference Report "Human Origins – Digital Future", July 27-31, 2020 - online

Databases are ubiquitous in science. They range from simple, thematically narrowly defined lists to very complex, interdisciplinary data networks. Despite their widespread use, questions of their linkage, targeted expansion and evaluation, as well as their sustainable preservation, often remain unresolved. To discuss current perspectives in this field, ROCEEH organized the international and interdisciplinary conference "Human Origins – Digital Future".

The aim of the event was to present and discuss integrative aspects and approaches to the development, use, and "future-proofing" of large scientific databases, especially in the context of archaeological and paleoanthropological research. The




▲ Figure 7. Detail of the Mind Map from Session 3 – Applications. To view the entire Mind Map, see ROCEEH's publication: DOI:10.1002/evan.21870. Graphics: M. Haidle.

primary research question was how databases with their innovative information technology can be used to generate new knowledge by retrieving, linking, and analyzing archaeological, paleoanthropological, paleo-biological, and paleogeographical information. In addition to fundamental questions of digitalization and open science, new approaches including innovative methods of data mining, machine learning, as well as deep learning and artificial intelligence were discussed. Supported by the Senckenberg Gesellschaft für Naturforschung, the conference took place online from July 27-31, 2020, with up to 70 simultaneous participants. The invited researchers presented their findings in a total of 15 talks, eleven short presentations, and four interviews.

The original planning of "Human Origins – Digital Future" as a three-day, face-to-face event at ROCEEH in Frankfurt/Main was revised in May, 2020 due to the developments of the COVID-19 pandemic. Instead, the conference was reconceived as an online event via Zoom. The sessions were spread over five days from 2-4 pm European time, so that presenters and interested parties from Japan to the U.S. West Coast could participate live with as few restrictions as possible. In addition, all presentations were recorded and could be accessed individually via ROCEEH's Nextcloud server for more than a month after the event. To make maximum use of the time, presentations were limited to 15 minutes. Most presentations were pre-recorded and then replayed during the conference. After each presentation, a speaker had five minutes for questions. These, as well as the concluding discussions after each session, occurred live with the opportunity for everyone to participate. The scheduled poster presentations were redesigned as short talks of about five minutes. Instead of a panel discussion at the end of the conference, ROCEEH staff conducted interviews with selected participants. These lively exchanges focused on future perspectives of working with databases in a prehistoric context. Leading off the daily introduction to the conference, the ROCEEH team summarized the previous day's results in an extended mind map (Fig. 7).

The conference was divided into five sessions covering databases, methods, applications, products, and perspectives. The main points addressed in each session are discussed briefly below.

## Session 1 - Databases

Chair: Volker Hochschild (ROCEEH). Speakers: Eric Grimm (Minneapolis, USA); Andrew Kandel (ROCEEH); Franco Niccolucci (Florence, Italy); Christopher Nicholson (Tempe, USA); Jesus Rodriguez (Burgos, Spain)

Prehistoric data and databases are numerous, but can vary widely. Integrative analysis on a large scale (e.g. big data) is hindered by the heterogeneity of databases. This in turn is determined by inherent data quality, systematic quality control, and maintenance—as well as uncertainties in the data regarding the "when, where and what". Databases differ in the level of documented entities (e.g. individual finds, inventories, localities, multiproxy datasets) and in their purpose (e.g. primary datasets, data integrators, repositories, publishers). The ephemeral nature of digital data (e.g., due to projects ending or outdated and proprietary software) was identified as a major problem that can only be addressed by specific curation. Applying FAIR principles as widely as possible was highlighted as an overarching goal: Databases should be Findable, Accessible, Interoperable, and Reusable.

Fundamentally, a prehistoric data science is essential for integrating elements of computer science with subject-specific competencies for archaeological, paleoanthropological, and environmental-historical questions, among others. The architecture and semantics of a given database are based on theoretical assumptions and questions that arise within each discipline.

### Session 2 - Methods

Chair: Christian Sommer and Ericson Hölzchen (ROCEEH). Speakers: Juan-Antonio Barcelo (Barcelona, Spain); Christian Sommer (ROCEEH); Ingo Timm (Trier, Germany); Alice Williams (Exeter, UK); Christian Willmes (Cologne, Germany)

Methods that are related to databases can have very different goals that can range from supporting data collection, improving data quality and creating ontologies, to generating data through simulation, modeling and prediction, and discovering hidden patterns in data as well as classifying and evaluating them. Specifically for the generation of new data and pattern recognition, big data is a prerequisite, as is the machine readability of the data. However, this is not a purely mechanical process; it always requires a theoretical background, a question, a critical reflection of the procedures, and a final interpretation. The data must be augmented and preprocessed, and a specific way to deal with gaps and uncertainties must be found. Reverse Engineering (reconstruction of development processes), Association Rule Mining (pattern recognition using data mining), and targeted archaeological investigations were presented as approaches. Further, from the fields of Artificial Intelligence (AI) and Machine Learning, supervised and unsupervised classification methods, agent-based modeling as an example of symbolic AI, Deep Learning as an example of sub-symbolic AI, and hybrid techniques were all addressed.

### Session 3 - Applications

Chair: Andrew Kandel (ROCEEH). Speakers: Rimtautas Dapschauskas (Heidelberg, Germany); Ewa Dutkiewicz (Berlin, Germany); Christine Hertler (ROCEEH); Zara Kanaeva (ROCEEH); Ana Mateos (Burgos, Spain); Shannon McPherron (Leipzig, Germany); Mika Puspaningrum (Bandung, Indonesia); Denné Reed (Austin, USA); Manuel Will (Tübingen, Germany); Andreas Zimmermann and Isabell Schmidt (Cologne, Germany); Ericson Hölzchen (ROCEEH)

Eleven thematically diverse applications were presented in short talks to address cultural relations, environmental reconstructions, culture-environment interactions (e.g. mobility, resource availability), population development, and human evolution. Using a variety of tools for data retrieval (e.g. query interfaces), visualization, and statistical analysis, questions were addressed in diachronic, cross-regional, and multidisciplinary frameworks. In the presentations and subsequent discussions, it became clear that databases and applications can serve varied purposes: from the collection, storage and analysis of data to their visualization and publication. By sharing data, databases facilitate collaboration, provide inspiration for new questions, and open up opportunities for Open Science. Depending on the problem, decentralized and non-standardized databases can be a useful addition to centralized organization. However, good documentation and publication are essential, even for databases that are not public.

### Session 4 - Products

Chair: Christine Hertler (ROCEEH). Speakers: Yasuhisa Kondo (Kyoto, Japan); Wolfgang Börner (Vienna, Austria); Tanja Neumann and Liane Giemsch (Frankfurt am Main, Germany); Matthias Lang (Bonn, Germany); Simon Goring (Madison, USA)

Products from and for databases include catalogs, search engines, repositories for code or for linking, where processed entities can include databases, their content, or maps. External, centralized storage facilities are an important product, especially for smaller projects. In addition to a long-term perspective, an open-source approach and an abstract but adaptable structure are fundamental, and user interfaces for evaluation are desirable. Depending on the services used, the costs for this need to be offset. Two examples from Vienna and Frankfurt presented products serving local population and tourists alike. Their content offers, among other things, an exhibition space to improve the visibility of research, different information formats, and even possibilities for participation through transparent governance (Open Government), Citizen Science, links to non-digital events, and individual approaches (e.g. of an artistic nature). One product that has ramifications for databases themselves is a research focus on the different kinds of databases and how they are used.

### Session 5 - Perspectives

Chair: Volker Hochschild (ROCEEH). Interviews: Sarah Kansa (Berkeley, USA) by Andrew Kandel (ROCEEH); Peter McKeague (Edinburgh, UK) by Volker Hochschild and Christian Sommer (ROCEEH); Julian Richards (York, UK) by Christian Sommer and Volker Hochschild (ROCEEH); Dieta Svoboda-Baas (Heidelberg, Germany) by Miriam Haidle (ROCEEH)

The final session highlighted resources (e.g. funding and staff) and the sustainability of existing databases as major challenges for how to deal with archaeological research data in the future. International data structures that provide infrastructure to manage and exchange data across countries will contribute to sustainability. By using different approaches such as offering flexible and complementary structures, proposing best practice examples, and linking datasets of high accuracy and detail, repositories can promote the preservation of databases and their continued use after the end of a project. Different data types (e.g., spatial information, text, object) present different challenges and have varied requirements. At the individual project level, the sustainability of databases is supported by adherence to FAIR principles, formulation of data management plans, integration into larger collaborations, conscious consideration of future users from the onset, and espousal of a "built to last" approach. In the context of the Open Data movement, general knowledge about dealing with data must be improved, and the user-friendliness of offerings must be enhanced. Data experts with a technical focus as well as explicit standards and criteria for handling data are required. However, Open Data cannot be provided for free; all participants should anticipate certain costs. In order to function in the long-term, fees for special services should supplement basic financing (e.g. through government funding). New digital forms of publishing, including databases, can expand the circle of authors (e.g. research projects, museums, universities, excavation companies, government agencies, independent researchers) as well as public outreach (e.g. scientists, consultants, decision-makers, processing artists and an interested public in general). For future results, emphasis should be placed on publications with and about data as well as interdisciplinary syntheses of new research questions. As a vision for this, a "Smart World for Paleoanthropology" was proposed on the second day of the conference.

All in all, the conference "Human Origins – Digital Future" offered an overview of a variety of facets related to the handling of data and databases on different prehistoric aspects, focusing especially on their further use beyond the specific timelines of projects. Individual focal points crystallized from the discussion and will be followed up in smaller scopes, such as half-day workshops. The online publication of the conference contributions is underway as a Propylaeum eBook with the Heidelberg University Press.

*Miriam N. Haidle*

## Forthcoming

- NECLIME

**19-22 April 2021,** online conference Paleoclimate, Paleovegetation, History of Biodiversity
Conveners: Angela Bruch, Torsten Utescher, Andrea Kern, Marianna Kováčová , Martina Stebich
For registration and more information please contact: abruch@senckenberg.de

- Menschsein // Die Anfänge unserer Kultur [Being Human // The Origins of Our Culture]

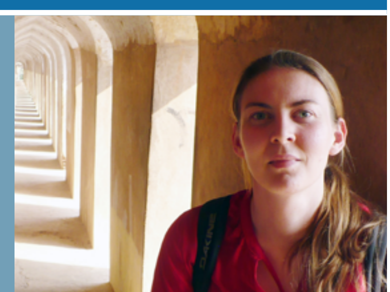
**5 May 2021-30 January 2022,** exhibition at Archaeological Museum, Frankfurt am Main, Germany
For more details see:
https://www.archaeologisches-museum-frankfurt.de/de/ausstellungen/menschsein

- 'Simulating Human Behavior - Targeted Design of Agent-based Models'

**4-8 October 2021,** digital workshop
in collaboration with the EUROPEANS project on targeted design of agent-based models to examine questions of human behavior and evolution.

## Who's who?

This issue: Susanne Krüger



**Susanne Krüger** studied Anthropology, Prehistory and Zoology at the Johannes Gutenberg University in Mainz. During her studies, she became increasingly interested in methods of diet reconstruction and modeling. In her Master's Thesis she analyzed the diets of Neanderthals. After completing her Master's Degree, she became involved with ROCEEH, where she worked as a research assistant, entering data of hominid and animal fossils into the ROCEEH Out of Africa Database (ROAD). She also began her research as a PhD student with ROCEEH. In her PhD Thesis she developed a model to reconstruct the diet of different species using diet reconstruction methods while considering the technological abilities of hominins, their behavioural performances, and the environment they inhabited. In this way, she was able to understand how different species used their habitats and to assess whether they were able to cope with different environments.

**CONTACT** The Role of Culture in Early Expansions of Humans
Heidelberg Academy of Sciences and Humanities

Senckenberg Research Institute Frankfurt/Main
Eberhard Karls University of Tübingen

**COORDINATORS** Miriam Haidle (scientific)
Julia Heß (administrative)

Senckenberg Research Institute
Senckenberganlage 25
D-60325 Frankfurt/Main
miriam.haidle@uni-tuebingen.de
julia.hess@senckenberg.de
www.roceeh.net

**EDITORS** Julia Heß and
Andrew W. Kandel

THE ROLE
OF CULTURE
IN EARLY
EXPANSIONS
OF HUMANS

The Heidelberg Academy of Sciences and Humanities is a member of the Union of German Academies of Sciences and Humanities, which coordinates the Academies' Program. The research project, "The Role of Culture in Early Expansions of Humans", was incorporated into the Academies' Program in 2008.

UNION
DER DEUTSCHEN AKADEMIEN
DER WISSENSCHAFTEN

March 2021