

STB/SBASG THEMATIC PROGRAMME PROPOSAL

ENVIRONMENTAL FACTORS IN THE CHRONOLOGY OF HUMAN EVOLUTION AND DISPERSAL (EFCHED)

1. INTRODUCTION

This is a four-year mini-thematic programme aiming to integrate and strengthen UK research in human evolution. The rationale underlying the proposed research and the timing of this programme is the acute awareness that studies of human evolution need to be tied closely to the ecological and environmental expertise underpinning Quaternary science generally, and that in particular research among the disciplines of palaeoanthropology, archaeology and palaeoecology needs to be integrated in an effective manner to realise these wider aims.

This programme will be highly interdisciplinary and has two parallel pathways. Firstly it will acquire and analyse new field data, thereby making a major contribution to human evolution and quaternary science. Secondly it will exploit existing datasets from archaeology, palaeoanthropology, palaeoecology, as well as genetics, within a developing E-Science context.

The pathways lead to several key issues relating to a fundamental, curiosity driven question:

- *What impact did environmental factors have on human evolution and dispersal?*

EFCHED aims to explore the interface between the disciplines engaged in human evolution research. These include the classic ones of human evolutionary studies - palaeoanthropology, archaeology and palaeoecology - as well as emerging ones such as evolutionary genetics and palaeoclimatic modelling, as well as allied disciplines such as neoecology (Figure 1). The relationship between environment and evolutionary change will be at the heart of EFCHED projects. Proposals will be judged by their commitment to the role of interdisciplinary approaches in investigating such fundamental relationships.

The mini-thematic programme will serve as a catalyst for a new integrative science within the field of human evolutionary research, and will provide training opportunities for the interdisciplinary postgraduate and postdoctoral researchers that the field urgently requires. The programme's output will be of wide public interest and serve as a showcase for NERC science policy and process.

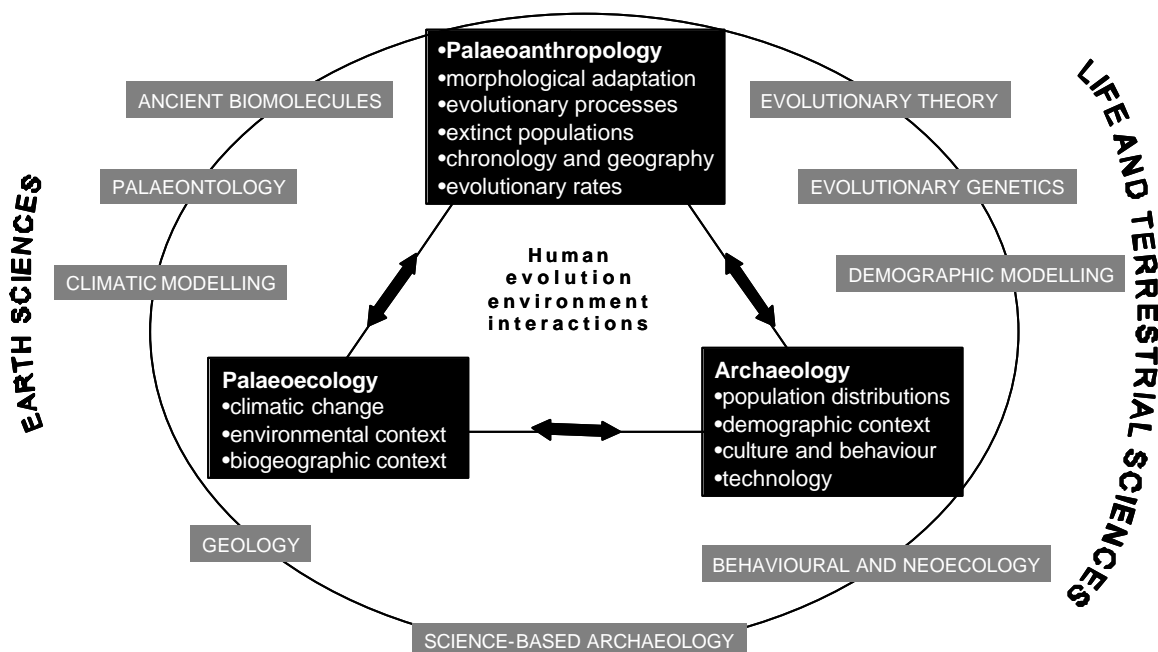


Figure 1: Schematic model of the interdisciplinary relationships involved in EFCHED

2. BACKGROUND

The background for this programme is:

- The UK has an internationally-recognised group of researchers working in this field. Our expertise is particularly strong in human morphology and palaeontology, Palaeolithic archaeology, Quaternary faunas, science-based dating, ancient biomolecules and human genomics. In all these fields we have led the way in developing the environmentally-based approaches that are now becoming a priority.
- The growth in evidence related to both human evolution and its environmental context leading to a need for more large-scale projects that can pull together case studies.
- The growth of molecular approaches to evolution which have opened up new issues (such as the debate about hominid and human origins) which depend upon timing and environmental context for resolution.
- The development of major new techniques, especially relating to environmental context and reconstruction, that have greatly expanded the data available and approaches possible to human evolution.
- Recognition that the relationship between humans and their environment needs consideration of organism-environment interactions at both ecological and evolutionary time scales.
- The great public interest in human evolution, evidenced in major TV documentaries, books and newspaper articles.
- The opportunity to exploit the growing availability of major palaeoanthropological and archaeological databases, programmes such as Rapid Climate Change (RAPID), and to bring a greater analytical dimension to studies of human evolution.
- The growing interactions between archaeologists, palaeoanthropologists, palaeoclimatologists and molecular biologists and the need to provide a new disciplinary framework in which they can work together.

3. NEED FOR A MINI-THEMATIC PROGRAMME

The EFCHED mini-thematic programme has a number of advantages over non-thematic funding:

- Providing a focused scientific response to the challenges posed by recent developments in human evolutionary studies, all of which have a strong environmental component (see Box 1).
- Providing the framework for strengthening long-term research on human evolution.
- Integrating the three essential components of human evolutionary research – primary field projects generating original evidence, laboratory analysis, and synthesis.
- Providing a sharper focus on evaluating and addressing key evolutionary questions.
- Providing a formal link between two fields that have grown together over the years – i.e. human-centred evolutionary and archaeological studies and quaternary science.
- Allowing greater exploitation of emerging scientific techniques, especially science-based dating, ancient biomolecules, evolutionary genetics, and palaeoenvironmental/climatic reconstruction.
- Providing a better way of integrating the development of scientific techniques (one of the great strengths of SBA) within problem-driven research.

Box 1: Recent Achievements in Human Evolutionary Studies	
Listed below are 10 examples of key discoveries and developments in human evolutionary studies that prompt environmentally-based approaches	
1.	The recognition of more than 15 species in the hominid fossil record, leading to questions about the environmental and climatic factors leading to speciation, extinction and isolation.
2.	The fact that bipedalism and brain enlargement evolved independently, at widely separated times, and in assorted environmental conditions.
3.	The identification of a major shift in body size and shape with the evolution of <i>Homo</i> , compared to <i>Australopithecus</i> , with the possibility that this is related to a major shift in the way the environment was used.
4.	The discovery through isotope analysis that the australopithecine diet may have been far more varied than had been inferred from classic morphological studies.
5.	The realisation that humans first occupied almost three quarters of the earth during only the last one per cent of the time since hominids first appeared
6.	The recognition that stone tools remain remarkably stable over long time-spans, and that technological solutions to survival among earlier hominids were not habitat specific. This implies that human culture is contingent upon both environment and phylogeny.
7.	The finding that there was a significant level of geographical isolation and evolutionary divergence among Middle Pleistocene hominids, and that this may have been related to changing environmental patterns associated with the onset of glacial cycles.

8.	The recognition, derived largely from molecular genetics that hominid evolution may have been characterised by extreme demographic instability, and that climatically driven population contractions and expansions may have given rise to our own species.
9.	The proposal that the early divergence of modern human populations may have been influenced by volcanic as well as climatic events.
10.	The discovery, through both archaeology, fossils and genetics, that the origins of modern humans is a localised African event, closely connected to the last two glacial cycles.

4. RESEARCH AIMS AND METHODS

The aim of the proposed theme is to encourage research that formulates and tests hypotheses on several chronological and spatial scales that bear on the causal relations between environmental and climatic change and human evolutionary patterns – genetic, morphological, behavioural and cultural. These relationships are epitomised in the questions posed at the outset, and from which more specific hypotheses can be derived – i.e. ‘what impact did environmental factors have on human evolution and dispersal?’.

The hypotheses will be tested through interdisciplinary projects that will include:

- The compilation of relevant archives and further enhancement via fieldwork, collections analysis and experiment.
- The analysis of evidence at a variety of geographical and temporal scales using a number of approaches including modelling, and comparative and experimental studies.
- New fieldwork to generate new data to answer specific questions
- Development of new syntheses based on comparison across time scales and regions.

5. RESEARCH THEMES

We identify two major related themes as lying at the heart of the EFCHED programme:

- *Humans in an evolutionary context*
- *Humans and dispersals*

Each of these sub-themes poses research problems that involve archaeologists, palaeoanthropologists, palaeoecologists, palaeontologists, molecular geneticists, as well as earth and life scientists more generally, although for each of them the mix and emphasis varies. These themes drive the selection of areas and time periods which will deliver appropriate data sets to achieve the programme aim.

5.1. Humans in an evolutionary context

It is second nature to archaeologists and palaeoanthropologists to be aware of the long term and dynamic nature of the human lineage, but this is still something that has not been operationalised through into many disciplines. Looking at humans in an evolutionary context – i.e. as a series of different species, with different morphologies, behaviours and ecological contexts – and using the excellent archaeological and fossil record documenting hominid presence (and absence) over a period of nearly 5 Myr allows a number of issues to be explored:

- Macro and microevolution: some hominid species living more than 4 million years ago were very ape-like, and their record is no different from that of any other mammalian Cenozoic lineage; others, such as Neanderthals, are richly recorded in both tools and bones, and have a span of only 200,000 or less. The process of transformation from one sort of creature to the other (when and how did it occur?) will be a challenge to many theoreticians and empirical scientists.
- The wealth of the hominid fossil record permits issues such as the timings of speciation and extinctions to be examined.
- The fossil record records the history of human morphological adaptations, and this can be used both to examine such major evolutionary issues as rates of change and also the actual nature of human biological adaptation.

The archaeological record (e.g. stone tools) provides the potential to study lineage persistence and distribution, and behavioural adaptation, not found in other species. As a result it potentially provides one of the best test-beds for general evolutionary hypotheses.

- A critically important and rapidly emerging field is that of evolutionary molecular genetics, and this is being used to reconstruct the phylogeny of humans and other species, to estimate coalescence events, and reconstruct prehistoric demographic patterns. However, there is considerable controversy about the underlying chronological assumptions, based on mutation rates and other internal inferences. The Pliocene and Pleistocene fossil records can be used to provide a broad comparative dataset through which calibration of molecular systems can be tackled.

- The development of bioinformatics has led to the potential to develop more sophisticated and analytical uses of chronological data (e.g. radiocarbon lists, etc.). This database approach ('palaeoinformatics') can be used to examine in detail the chronological patterns of human distributions in the environment.
- The period in question (5 – 0 Myr) covers times in which very different chronological resolution is possible, from the early part where chronology is measured in 10^5 y to the recent end, where a resolution of 10^2 y may be possible. Within these scales is the fact that some archaeological contexts allow 15 minute activity episodes to be observed. One of the tasks for an evolutionary explanation lies in the integration of different time scales.
- The growth of palaeoinformatics allows testing across dating methods and scales, and thus develops a more stable chronological framework for scientists from a number of disciplines.
- The impact of rapid climatic change on human society, as revealed for example in the chronological precision now provided by the Greenland ice cores, can now be investigated at a variety of scales and the outcomes observed.

5.2. Humans and dispersals

The course of human evolution sees hominids changing from a group of geographically restricted African species to a single global species. There is thus a strong geographical, and therefore ecological, element to hominid evolution, and a key aim will be the investigation of the patterns and processes by which hominids repeatedly dispersed and contracted across landscapes at all scales. A major question to ask is, what role did environmental change play in the observed pattern? Understanding the geological context at a variety of scales and processes provides the critical framework for this theme

- Dispersals are strongly influenced by environmental effects, and it will be a major part of the theme to investigate the timings and distributions of dispersals in relation to local and global patterns of climatic/environmental change.
- Dispersals are also strongly influenced by the behaviour of the hominids, including their technology, and comparing patterns of dispersals across different human populations will show the role of changing behaviour in the distributions and persistence of human groups.
- Dispersals and contractions form the basis for biogeographical patterns, for both humans and other species. Allopatry, isolation, and admixture are all major evolutionary factors, and identifying corridors of dispersals, refugia, and contact zones will be of use to ecologists, geneticists and other scientists.
- As populations disperse – or contract into refugia – they come under new selective influences and contexts for genetic drift. Hominid morphology thus has a strong geographical component that can only be understood by bringing together ecological factors with the historical contingencies of the populations.
- At the macro-level it has been proposed that pulses of speciation and extinction have been directly related to major climatic change. The theme will explore this issue in terms of geographical variation, taxonomic differences, and rates of change.
- Embedded within global patterns of change are local processes, varying from regional climatic patterns, shifts in sea and lake levels, and tectonic/volcanic effects. These are the ones that directly impinge on human and other populations, and one focus will be the discerning of such local patterns within larger scale changes.
- During most of human evolution the direction of influence has been the environment acting as the selective pressure shaping human morphology and behaviour. The morphological and behavioural patterns observed in the fossil record will be screened for the effects of environmental change.
- With the emergence of modern humans and the global expansion of population the direction of causality shifted, and humans increasingly influenced their environment. Mapping this process and its effects within a geological framework will be a major area of research

6. DELIVERABLES

The principal deliverables relevant to the wider scientific and public community will be:

- A new understanding of our position as a dominant global species and implications for our future.
- An improved understanding of rates and scales of climate and landscape change, and how these impacted both on human evolution and dispersal.
- A more precise appreciation of how human evolution is affected by rates and scale of environmental change
- An evolutionary context in which the results of post-genomic research will be understood.
- Stronger co-operation between collaborating disciplines engaged in human evolution research.

The principal benefits for human evolutionary studies and SBA will include:

- Achieving greater confidence in the correlations between the archives of archaeological, palaeoanthropological, genetic, palaeoclimatic and palaeoenvironmental data.
- Improved knowledge of the adaptive and phylogenetic diversity of hominids and their cultures set in a palaeoenvironmental context.

- A more detailed understanding of the role of differences of scale, both temporal and geographical, in evolutionary development.
- Understanding the Quaternary legacy for modern human diversity, both morphological and genetic.
- A better-focused integration of the environmental factor in human evolution and the ways in which specific variables of landscape structure and dynamics have selected for, or been selected by, changes in behaviour.
- The development and testing of predictive models (using GIS) of the spatial and temporal distribution of hominid populations and their inter-connections at the global scale, using genetic, morphological and archaeological data as the control.
- Combining better population genetic models with information from independent and multiple sources of data to increase the value of human evolution as a framework for new genomic studies.
- Enhancement of modelling techniques to simulate how genetic and demographic structures can emerge from hominid palaeontological and archaeological empirical observations.
- Database of high-resolution terrestrial palaeoenvironmental records for key periods by integrating existing and stimulating the collection of new proxy records.

7. RELEVANCE TO NERC: NATIONAL AND INTERNATIONAL DIMENSIONS

NERC's Strategy for Science-Based Archaeology identifies three key initiatives which are directly addressed in this programme; Refining the chronology of the human past, Human evolution, ecology and behaviour and biomolecular archaeology. The proposal fits squarely into two of the six "science opportunities" identified by the Science and Technology Board sectoral strategies which are: Climatic and Environmental Change and Evolution of the Biosphere and the global environmental change area of core science. The programme builds on the previous SBASG Thematic Programme, the Ancient Biomolecules Initiative (ABI) and dovetails with the new RAPID programme. Recent NERC initiatives in E-Science will also impact on this programme.

Nationally, the Prehistoric Society in its 1999 report "Research Frameworks for the Palaeolithic and Mesolithic of Britain and Ireland", sponsored by English Heritage, identified the issues of dispersal as being central to future research. This report has been acted upon by English Heritage, which has commissioned further scoping studies for research investment. The Stage 3 Project, run through the Godwin Centre at Cambridge, provides a successful model for international, interdisciplinary research.

The international importance of human evolution is demonstrated by the National Science Foundation (USA), "Human origins initiative" currently under consideration as a ten year proposal. European interest in human evolution research is delivered, among others, through the ESF, CNRS (France) and the Max Planck Institute (Germany). UNESCO's World Heritage List contains sites relevant to human evolution in four continents. INQUA now has a sub-commission on climatic imperatives and historical contingency.

8. UTILITY AND BENEFICIARIES

A prime benefit of this Programme would be an increased and intensified interaction between diverse scientific disciplines encompassing a wide range of environmental, biological and historical sciences. Of necessity, this requires a world-wide perspective and offers exciting possibilities for international collaboration. It also demands explicit recognition that the collaboration of experts in fields outside archaeology and anthropology is more effective when the various investigations are formulated to include objectives that are of direct interest to the supporting sciences. The co-ordination through EFCHED of these potential co-funding partners will benefit NERC by extending the application of skills and the shared use of facilities and equipment.

The proposal builds on recent NERC, JIF and Wellcome investment (the Radiocarbon Accelerator and Ancient Biomolecules Centre at Oxford) the AHRB Research Centre for the Evolutionary study of Material Culture at UCL and Southampton and Cambridge's £5m award from Wellcome, Leverhulme and SRIF to establish a Centre for Human Evolutionary Studies, all of which offer the potential for training PDRAs with an interdisciplinary focus. Furthermore, the proposed programme will be of direct benefit to all scientists interested in human response to global climate change, and ultimately to policy makers. It will also be of direct relevance to organisations such as English Heritage, currently funding internationally important investigations of early hominid occupation on the Sussex coastal plain, and who are charged with managing and presenting the human heritage. EFCHED funded projects will be expected to produce materials which bring human evolution alive for the public. Involvement with the media to explain the process of science and the role of research councils such as NERC is seen as important to the programme.

9. TRAINING

The opportunity to train Postgraduate and Postdoctoral researchers within an interdisciplinary research programme is a key objective of EFCHED. The programme will break down disciplinary boundaries both through the requirements to train skilled practitioners in the structure of the varied data archives, and also in the range of scientific techniques and methods which are needed to interrogate them. The programme provides the potential to shape the next

generation of researchers and equip them with the skills and interdisciplinary dialogues that only come through engagement with cutting-edge science. This will be achieved by tied studentships and project based PDRAs. It is to this cohort that we look for the new disciplinary framework focused on integrated human evolution rather than its current constituent parts. We predict that such a lead will also initiate a sea change in the structure of graduate training programmes. In particular we envisage inter-institutional collaboration that will share expertise and broaden the student experience. Human evolution is an international subject and we see opportunity through such initiatives as the World-Wide University Network, linking UK and US universities, to further demonstrate this claim.

10. RESOURCES

EFCHED is a two million four year mini-thematic programme starting in 2002 .Within this budget there is a commitment for for data management of the bioinformatic archives. EFCHED will be organised through a scientific management committee which is drawn from all the major relevant disciplines. £120K is estimated to cover central project costs, which allow for a Town Meeting, archive standards conference, annual workshops, and web-site dissemination. The Chairman will act as programme co-ordinator and resources will be made available to support this role. The programme will be organised and resources allocated through one open call for project bids. The call will consider bids in the following areas: Bioinformatics which assess, compile and calibrate archives, laboratory and experimental projects, modelling and fieldwork.

Programme Schedule

Year	01/02	02	03	04
Establish Management Committee	•			
Town Meeting	•			
First Call, Outline Bids and full bids	•	•		
Workshops		•	•	
Archive Standards conference			•	
Finale				•

11. CO-FUNDING ARRANGEMENTS

AHRB has as a designated funding area the archaeology of human origins and through its Research Centres scheme offers further potential for co-funding. English Heritage's long term support for The English Rivers Palaeolithic Survey and the Boxgrove Project has been continued with projects, especially relevant to this programme at Cromer, the Sussex raised beaches and under consideration GIS based surveys of the Upper Palaeolithic and Mesolithic. The Wellcome Institute through its science based archaeology panel has a declared interest in human evolution. Leverhulme currently is calling for proposals relating to human evolution and archaeology. The BBSRC currently has a Bioinformatics programme and funding in this area is likely to expand across many funding bodies over the next few years. The British Academy has collaborative funding arrangements with CNRS that can be built on and a Larger Research Grant for funding pilot projects.