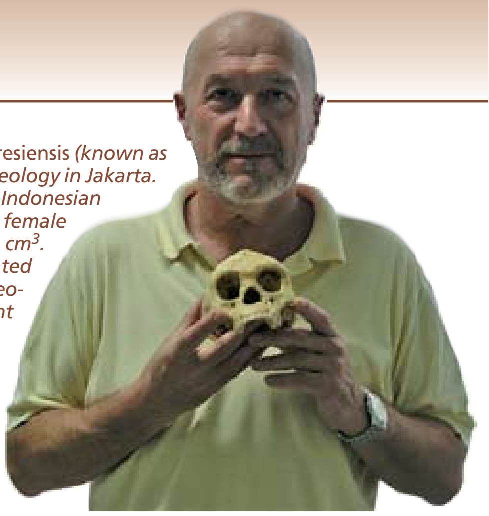
Claudio Tuniz

Out of Africa



Claudio Tuniz holding the skull of Homo floresiensis *(known as the hobbit) at the National Centre for Archaeology in Jakarta. This skull was discovered in 2003 on the Indonesian island of Flores. It belongs to an adult female about 1 m tall with a brain of about 400 cm^3. The radiocarbon age of charcoal associated with the skeleton is 18 000 years. Palaeo-anthropologists suspect the hobbit might belong to a more archaic genus than* Homo

Evidence is mounting that we all hail from Africa. But when did this migration of anatomically modern humans begin? How long did it take for them to reach all corners of the Earth? And what do we know of our ancestors' way of life and their impact on the environment?

Nuclear physicist Claudio Tuniz has been studying these questions for many years, most recently in his capacity as Assistant Director of UNESCO's International Centre for Theoretical Physics (ICTP) in Trieste (Italy). At first glance, the link between physics and human evolution may not be obvious. Yet, the tools of modern physics can date human evolution and dispersal accurately. Prof. Tuniz has gone from using particle accelerators to measure the age of meteorites and lunar rocks to using them to pinpoint the age of human bones and teeth.

On 29 April, he was in Venice to describe how the latest developments in physics are being used to study evolution, on the eve of UNESCO's symposium on Darwin, Evolution and Science. Prof. Tuniz is also commemorating 'the Darwin year' with *The Bone Readers*, a book he has just published with co-authors Richard Gillespie and Cheryl Jones; it chronicles the science, political debates and cultural sensitivities surrounding the study of the origin of Australian Aborigines.

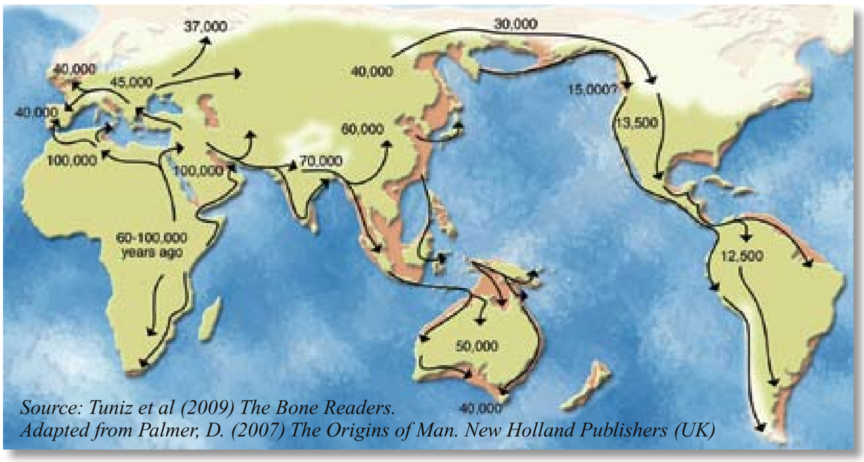
Where do we come from?

There are two main theories on the origin of modern humans. The 'out of Africa' theory puts our species' roots in Africa. The rival multiregional theory states that modern humans evolved simultaneously in various regions. Multiregionalists contend that modern humans in Southeast Asia and Australia evolved from Java Man and that the Chinese descended from Peking Man – both Java Man and Peking Man belong to the species *Homo erectus* – and that Europeans descended from the Neanderthals. However, DNA evidence strongly supports the Out of Africa theory and proponents also claim strong support from bones.

How did human beings disperse?

Population genetics studies suggest that, about 70 000–80 000 years ago, a group of fewer than 1000 modern humans migrated from Africa, where they had evolved from a more archaic *Homo* species about 200 000 years ago. First, they spread eastwards, arriving in Asia and in Australia. They would only reach Europe 40 000 years ago and the Americas about 13 000 years ago. Along the way, they left some clues – bones, teeth, stone tools and remains of human food – that can help us trace their path.

DNA analyses can verify this type of archaeological information. The recent dating of sediments associated with stone tools from India put the artefacts at 77 000 years old. The study of genetic mutations suggests that modern humans travelling from Africa should have arrived in India 60 000–70 000 years ago, so, in this case, the DNA analysis corroborates the archaeological data. The same correlation exists in Australia and in the Americas: DNA analysis supports archaeological evidence that Australia was populated about 50 000 years ago and the Americas 11 000–16 000 years ago. In both cases, the arrival of humans coincides with the demise of the megafauna, the large animals that populated these lands during the ice ages.



Source: Tuniz et al (2009) The Bone Readers.
Adapted from Palmer, D. (2007) The Origins of Man. New Holland Publishers (UK)

Dispersal of modern humans according to genetic and archaeological evidence. Coastlines during glacial times are shown in pink

What role does physics play in the study of human evolution and dispersal?

In the mid-19th century, Charles Darwin and geologists of his time already had a sense that the Earth and its living creatures had a very ancient origin but they lacked a quantitative method to prove their theory. That became possible only at the end of the 19th century with the discovery of radioactivity.

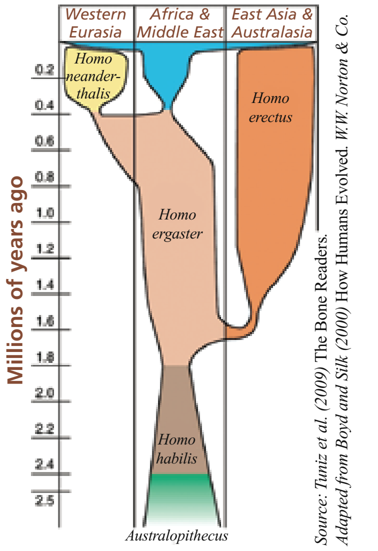
Modern techniques based on radioactivity help us pinpoint precisely the chronology of human dispersal and evolution.

There are several methods, depending on how far back you want to go. The radiocarbon method, based on radionuclide carbon-14 produced in the atmosphere by cosmic rays, can date material to about 50 000 years. Another method known as cosmogenic dating uses long-lived radioactive isotopes of aluminium and beryllium generated when cosmic rays bombard the Earth's surface. It can reach back more than one million years. Still other methods are based on the radioactivity of uranium and on the effects of natural radioactivity on sand grains, known as optically stimulated luminescence dating. There are many others.

Cosmogenic dating was used recently to date Peking Man, one of the archaic hominins from which modern humans probably evolved in Africa, to nearly 800 000 years ago. Peking Man's ancestors would have left the African continent in an earlier exodus, probably 2 million years ago. Over this period, the Earth's climate went through several ice ages. During the coldest period of the last ice age 20 000 years ago, layers of ice 1 km-thick covered most of Europe and North America. Sea levels dropped by up to 120 m, opening up new corridors between continents. The 'isotope language', expressed in oxygen and hydrogen isotopes in deep-sea sediments and Antarctic ice cores, speaks volumes about ancient climate.

Scientific tools and procedures developed mainly in physics research can be used to examine ancient hominin teeth and bones and for the non-destructive examination of vases, spears, porcelain and other archaeological finds. These tools include new microscopes based on synchrotron radiation, neutrons and high-energy ion beams that can reveal the structure and composition of cultural artefacts.

In the 1980s, I used synchrotron radiation to study the diet of ancient Normans from Sicily and southern Italy where they established a kingdom in the 11th century AD. I used material from teeth to gain insights into their diet. We are now analysing a tooth from a man found in Visogliano near Trieste, who, according to many palaeoanthropologists, is the common ancestor of the Neanderthal and modern humans. He is a member of the species *Homo heidelbergensis* and is almost half a million years old. We are also considering the possibility of using cosmogenic dating – the method I employed many years ago to date Antarctic meteorites – to pinpoint his age more precisely.



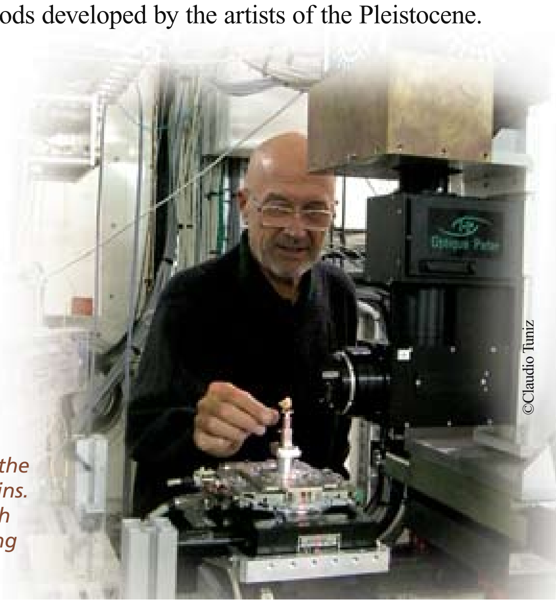
According to this model of human evolution and dispersal, H. ergaster *evolved in Africa 1.8 million years ago before spreading to Asia where it evolved into* H. erectus. *The blue shading represents* Homo sapiens

How could physics be used in future to study human evolution and cultural heritage?

New x-ray techniques enable us to make out minute details in bone and teeth to track evolution. Synchrotron radiation allows us to generate three-dimensional (3D) images of bones and teeth at thousands of times the resolution of ordinary x-ray images without destroying the specimen. We are presently applying this technique to the archaic hominin I mentioned earlier, *Homo heidelbergensis*. The European Synchrotron Radiation Facility (ESRF) in Grenoble (France) is at the forefront in this field but we have similar projects at the ELETTRA synchrotron facility in Trieste.

The SESAME project – for Synchrotron-light for Experimental Science and Applications in the Middle East – has set up a research centre in Jordan under the auspices of UNESCO which is planning a programme dedicated to archaeology and cultural heritage. This is a topic of paramount importance to the Middle East, where modern humans first met the Neanderthals 100 000 years ago. The region is also rich in cultural heritage from historic times that needs to be preserved and studied. The UNESCO Secretariat and ICTP are actively involved in these programmes.

At the ICTP, we are constructing a portable x-ray spectrometer in collaboration with ELETTRA that will allow us to analyse *in situ*, without collecting samples, the rock art from the Kimberley and Arnhem Land of northern Australia to understand the methods developed by the artists of the Pleistocene.



Claudio Tuniz using synchrotron radiation (bright x-rays) at the ESRF to generate a 3D image of the tooth of an archaic hominin at thousands of times the resolution of ordinary x-ray images. Known as microtomography, this technique promises to unlock the secrets of the developmental biology of Neanderthals, Homo erectus *and other hominins. Using the synchrotron, scientists at the ESRF recently discovered that Neanderthal tooth enamel was thinner than that of modern humans, supporting the hypothesis that young Neanderthals grew to adulthood faster than* Homo sapiens. *Synchrotron radiation is produced by an electron beam accelerated in a ring at almost the speed of light*

The analysis of complete mitochondrial DNA sequences from relict populations in Eurasia suggests they arrived in India 66 000 years ago. A study of stone tools from the site pictured in Andhra Pradesh in India supports the genetics. Dated through optically stimulated luminescence by an Australian group, the site contains artefacts made as early as 77 000 years ago and is claimed to be the oldest Homo sapiens *site in India. The artefacts were found in sediment layers above and below fine ash from the super-eruption of the Toba volcano in Sumatra 74 000 years ago. The eruption was the biggest volcanic explosion in the past two million years, hurling 2700 km^3 of rock and ash into the atmosphere*

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This tool could also be taken to African museums for use in studies aimed at preserving and understanding materials relevant to human evolution. The analysis could be done locally, without displacing precious, fragile human remains.

Last but not least, we are planning to use cosmogenic dating to confirm the chronology of human remains aged from 500 000 to 1.5 million years. This is a critical period for human evolution and it is important to corroborate other dating techniques that still have large uncertainties.

How did you come to be interested in human evolution?

I have always had an interest in human evolution and archaeology. After spending several years doing pure nuclear physics, I realized that some of the methodology could be applied to many other areas. In the 1980s, I applied x-ray and accelerator methods to studies of cultural heritage and, in the 1990s, I used accelerator-based radiocarbon dating in Australian prehistory. I became very interested in how methods from nuclear physics could be used to study and preserve cultural heritage.

Prehistoric cultural heritage is very important for the cultural identity of indigenous groups like the Aborigines in Australia and native populations in North America.

Tell us about *The Bone Readers*

In this book, we examine the facts about the first human arrival in Australia, what modern DNA tells us about the origin of Australian Aborigines, theories on the Indonesian 'hobbits' and who or what killed off Australia's giant marsupials. The findings from Australia and its neighbours are echoed in debates over the demise of the Neanderthals and shed light on human evolution. We also discuss how politics and ideology can interfere with the scientific method. There are tensions between science, the management of cultural heritage and the beliefs of the first peoples.

The Australian Aborigines have asked museums and other institutions worldwide to return the bones of their ancestors, including those that belong to their distant past, with ages up to 40 000 years. As we say in our book, '*The controversy has its roots in Australia's colonial history. Dismissed in the 19th century as primitive and locked in the Stone Age, [the Aborigines] were viewed as interesting specimens by natural historians in the colonies and Europe. The bones of at least 3000 individuals were sent overseas to 70 institutions or more in 21 countries for their collections*.' Today, when museums return very old human bones to them, Aboriginal communities tend to bury or cremate them, as they consider these bones as belonging to their ancestors.

This creates some tension with the scientific community. In our book, we explain that '*many scientists and archaeologists contend that ancient remains are the common heritage of humanity. Research on skeletons could shed light on the life expectancy, health, cultural practices, diet and mobility of past populations. And Australian remains could help settle debates in human evolution*.'

Some Aborigines have also opposed projects based on DNA analysis, like the international Human Genome Diversity Project of the 1990s. It set out to sample the DNA of 100 000 people from between 400 and 500 populations. One of its drawbacks was a plan to preserve some of the DNA material as cell lines. This was abhorrent to some Aborigines. Scientists need to be aware of cultural sensitivities.

Many Aborigines also associate science with the Western world, with the colonisers. When they do, I like to cite ICTP founder Abdus Salam, who used to say that '*scientific thought is the common heritage of humankind*'. Some Aborigines from northern Australia are happy with this idea and would like to be involved in a project where scientific methods are integrated with traditional knowledge. Their oral tradition has been passed on for hundreds of generations, so they say science will only confirm what they already know!

There is still a lot to learn about northern Australia. The Aborigines I have spoken with there would be happy to collaborate with scientists. It is important to decipher, in a non-invasive way, the information carried in cultural artefacts and their connection to the culture of the people who made them. I think there is an important opportunity here for the UNESCO Secretariat and the ICTP could play a role too.

Interview by Mary Ann Williams[1]

Extracts from The Bone Readers *are available at the publisher's website: www.allenandunwin.com The book is also published by Left Coast Press (USA) and Springer (Italy).*

1. *ICTP Public Information Officer: mwilliams@ictp.it*