If Indiana Jones[1] were to set out on a quest today, rest assured that it is not the Ark[2] given by Yahveh to Noah that he would be seeking, but the old Patriarch himself, or rather, the remains of his bones and flesh. That is because archaeologists around the world are turning to a new source of material evidence: DNA[3] from organisms which were once alive, refered to as "ancient DNA". This term describes the DNA fragments that can be found in some types of preserved (e.g. mummies) or fossilized biological material.

Of all the non-biological disciplines in which ancient DNA is now being used as a source material, archaeology is perhaps the one with the most to gain from ancient DNA. Analysis of ancient DNA can potentially make major contributions to both the interpretation of individual archaeological sites, and the development of hypotheses about past populations. It can do so by confirming with greater accuracy hypotheses based on traditional methodologies, as in gender determination of individuals, which used to be based on context, artifacts, and morphometric measurements of bones. More interestingly, ancient DNA is a route to previously inaccessible information, such as the degree of kinship between the remains of different individuals, or the patterns of population migrations which are so far based on inferences from the genetics of modern day populations.

In what follows, I hope to convince the reader that molecular archaeology — as the study of ancient DNA for archaeological purposes is sometimes called — brings us closer than ever to making the past come alive. I will also explain why I believe molecular archaeolgy to be both worthwhile and possible for Lebanese archaeologists, in general, and for an institution such as the National Museum, in particular, to embark on this scientific journey.

Since the elucidation of the structure of the DNA molecule in the 1950's, and the subsequent findings, metaphorically described as "the cracking of the code of life," molecular biology has emerged as a separate discipline within biology. Its main concern is to understand the functioning of living cells at the molecular level. Molecular biologists have been developing increasingly sophisticated and powerful methodological tools to get at this issue. In addition to greatly expanding the scope of the other biological fields (genetics, neuroscience, development and embryology, evolution...) these technologies for analyzing and manipulating DNA are being successfully used in non-biological fields as disparate as forensic science, genetic counseling, environmental policy, and archaeology.

For archaeology, it all started in the early 1980's, 1984-5 to be precise. With painstaking effort and admirable perseverance, Dr. Svante Pääbo cloned[4] fragments of DNA from samples of Ancient Egyptian mummies kept in Sweden at the University of Uppsala's Egyptian antiquities.[5] A few months earlier, a group at Berkeley had managed to demonstrate that DNA could be recovered from organisms long after their death.[6] Their source material had been skin from a quagga, an extinct member of the horse family, a specimen of which was kept at a German museum. Pääbo's experiment confirmed the Berkeley group's findings, and represents the first time ancient DNA was used for archaeological purposes. Despite the exciting news, these two experiments made a discouraging point: that ancient DNA was very damaged, making its cloning extremely laborious and error-prone. At the time, in Pääbo's words, "the study of ancient DNA could not qualify as a fully respectable science."[7] That was before the mini-revolution which occured in 1985. This is the year that will be remembered in molecular biology as "the year of PCR." PCR, or the polymerase chain reaction, is a cloning technique of extraordinary sensitivity and power developed by Kary B. Mullis, who obtained the Nobel Prize for it. PCR allows the multiplication of a fragment of DNA in a test tube, with no intermediate steps. Moreover, it is less sensitive to the damages caused in a DNA sample by time or by damaging agents. It became immediately clear that PCR could open great possibilities for the study of DNA sources such as ancient DNA, which are small, scarce, damaged, and precious.

The promise held by PCR was tempered by the methodological challenges still facing the study of ancient DNA. Some have since been resolved: while analyzing 7,000 year old human brains, the Wilson group, joined by Svante Pääbo, developed ways to overcome the inhibition of PCR that was due to impurities in the source material. Another PCR-related problem is contamination. PCR is such a sensitive method, that it can amplify even minute amounts of contaminating DNA. These technical problems have been addressed one by one, and a series of guidelines, summarized in a 1994 article[8], has been established. The ability and willingness to address concerns about reproducibility and credibility has now given the field full scientific status.

The reader may be convinced by now that the study of ancient DNA promises archaeology new insights via access to previously unavailable information, and that the field is now scientifically respectable. All one needs now is some specific examples of how ancient DNA studies can help make a difference. In a current project, researchers have undertaken a DNA-based kinship study on a Bronze Age burial site, which will help them infer the importance of the family group in the social structure of the group studied. The kinship parameter is the single most important one in this case, and was impossible to assess before the advent of ancient DNA studies. In some cases, it may be important to determine the gender of an individual's remains, as, for example, when trying to document a gender bias in death. This may happen in societies where one gender is given less care than the other. Traditional methods of assessing gender of adults are reliable, but such is not the case for juvenile skeletons. DNA analysis can now be used to provide this type of information, thus allowing inferences about the social habits of the population being studied. Another controversial issue in archaeology is human mobility, particularly of ancient populations. The possibility of making a more accurate investigation of past migrations by directly examining DNA from remains representing the migrating populations, or their immediate descendants, is being explored by a number of groups. One of these groups working on the colonization of the central Pacific has managed a striking demonstration of the role that ancient DNA can play by forcing the reappraisal of the existing migration model based on linguistic and archaeological evidence. Note that the Middle East is often mentioned in articles on the promise of ancient DNA, but nowhere does one find any indication of work in progress...

As early as 1991, the year of the First International Congress on Ancient DNA in Nottingham, England, it had become apparent to everyone that "ancient DNA was no longer just a curiosity, but an area where systematic studies can produce insights unavailable by any other technique." In the words of a reporter covering the conference for the journal Science, "for archaeologists, anthropologists, and palaeontologists the message is clear — the time has come to ensure that textbooks on the polymerase chain reaction and gene cloning are on the bedside table."

The techniques of molecular archaeology are undoubtedly sophisticated and expensive, which makes them seem out of reach for Lebanese archaeology. On the contrary, the skills and training required for studying ancient DNA have already been aquired by a plethora of Lebanese men and women engaged in molecular biological research abroad, and molecular biology laboratories are currently being set up by universities in Lebanon. Furthermore, leaders in the field of molecular archaeology such as Dr. Pääbo (currently at the University of Münich) and others are readily available for advice on the specific procedures required for generating reliable and reproducible results. By entering the field of molecular archaeology, Lebanese archaeologists and the National Museum (possibly in collaboration with Lebanese and foreign scientists abroad and in Lebanon) have the opportunity of becoming the Middle East leaders in the field. Let us keep in mind the incredible wealth of ancient DNA sources in our region, owing to the antiquity of our history, its complexity, and a climate favoring the preservation of biological material. My thanks to Drs. D. A. Feldheim (Harvard Medical School), A. Sidow (Massachusetts Institute of Technology), and Svante Pääbo (University of Münich) for help in researching this article.

Notes

1 Fictional archaeologist/adventurer played by Harrison Ford in a series of movies by director Steven Spielberg.

2 Ark of the Covenant, in "Raiders of the Lost Ark," the first in the above cited Spielberg movie series.

3 DNA, or deoxyribonucleic acid, is the molecule that encodes hereditary information for all living organisms. DNA molecules are long stretches of four alternating molecular "letters" composing "words," the genes. Each cell in the body of a given living organism contains the same complement of genes. In a living cell, DNA is duplicated before the cell divides, and each copy of the whole complement is incorporated into one of the daughter cells arising from the division. Each of the "words" (genes) in DNA can also be read and used as a blueprint to make a particular protein with a preset role in maintenance and functioning of the living cell.

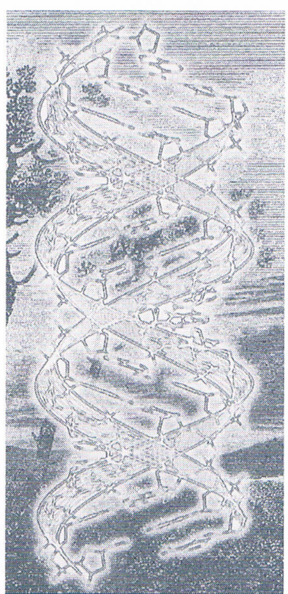
4 In molecular biology jargon, cloning refers to a technique which generates numerous copies of a single DNA fragment. It consists in the insertion of a fragment of DNA of interest into a specially designed DNA "vector." The vector containing the cloned fragment can be introduced into bacteria, which can replicate it in large amounts. The amplified vector can later be harvested, and large quantities of the DNA fragment can be recovered via excision from the vector. This DNA can then be analyzed and manipulated without the concern of loosing the fragment. Provided the bacteria containing the vector are properly conserved, virtually infinite quantities of the DNA fragment can be obtained.

5 S. PÄÄBO in "Nature" vol. 314, pages 644-645; 1985: "Molecular cloning of Ancient Egyptian mummy DNA."

6 R. HIGUCHI, B. BOWMAN, M. FREIBERGER, O.A. RYDER AND A.C. WILSON in "Nature" vol. 312, pages 282-284; 1984: "DNA sequences from the quagga, an extinct member of the horse family."

7 For PÄÄBO's account of the beginnings of ancient DNA studies, see "Scientific American," pages 86-92; November 1993: "Ancient DNA."

8 O. HANDT, M. HOSS, M. KRINGS, AND S. PÄÄBO in "Experientia" vol. 50, pages 524-529, 1994: "Ancient DNA: Methodological challenges."


DNA configuration