Ancient DNA

Ancient **DNA** (aDNA) refers to DNA extracted from ancient specimens. Examples include the analysis of DNA recovered from archaeological and historical skeletal material, mummified tissues and archival collections of non-frozen medical specimens. The techniques used in extracting aDNA are however applicable to any situation where DNA has degraded to the extent that conventional fresh DNA extraction techniques cannot be used. Practically speaking, the term aDNA relates to the condition of the DNA, not necessarily the age.

Different techniques are required to extract ancient DNA, and the extraction therefore needs to be handled at a specialist aDNA laboratory. A fresh DNA sample can be on the order of micrograms. If the lab is exposed to low levels of alien DNA on the order of nanograms or picograms, the contamination will not show up in the results. In contrast an aDNA sample is typically on the order of nanograms or even picograms, so that extra nanograms or picograms of contamination could be fatal to the analysis.

The issue with aDNA extraction is simply that DNA is a very complex structure that degrades as soon as the organism dies due to bacteria that cause the corpse to decompose. This is accelerated if the DNA is exposed to "the elements", and by any chemicals that might be present (such as embalming fluid). The oldest specimens that have yielded aDNA tend to be found in cool dry climates at high altitudes that helped retard the bacterial action and kept the DNA away from heat and moisture

The Y-chromosome is almost 60 million base pairs (/wiki/8aseyair) long and there is only one per cell. DNA analysis of the Y depends on extracting enough DNA from certain regions within those 60 million base pairs for analysis. For highly degraded remains, it's highly unlikely that enough of the right Y survives for analysis.

There is a much better chance of recovering enough mitochondrial DNA (mtDNA) for an identification. This makes it easier for the laboratory to extract usable DNA, but a lot harder on the genealogists looking for the family reference, as you have to follow the female line. There are up to 1,000 mitochondria per cell, each with five to ten copies of its own 16,569 base-pairs genome. Therefore, there can be as many as 10,000 copies per cell of the mtDNA genome. This results in a much higher probability of recovering mtDNA from severely degraded remains.

Embalming creates further problems. The formaldehyde found in embalming fluid not only denatures DNA, but also causes DNA strands to cross link to themselves and other strands of DNA, much like a wadded up ball of duct tape. The damage is permanent. The formaldehyde oxidizes to paraformaldehyde, which can inhibit the Proteinase K used during the extraction. So for embalmed remains, the extraction of aDNA must overcome the issues of degradation by bacterial action involved in decomposition and degradation due to exposure to the elements, in addition to the inhibition of the extraction process by the presence of oxidized formaldehyde. There have been protocols developed to try to break the cross-links formed by the formaldehyde. These involve microwaving and temperature cycling bone powder. Unfortunately, for very fragile specimens, this protocol can destroy the DNA as well. What has been more successful is to soak the bone powder in a PBS solution that allows the paraformaldehyde to float to the top, with the bone powder sinking to the bottom. Once the paraformaldehyde is removed the remaining bone powder is dissolved with a demineralization process, releasing DNA that is hiding deep in the bone matrix that has not been affected by the embalming process. This can double the yield of aDNA.

The best place to look for aDNA is in teeth. Enamel is the hardest substance in the body and although it does not contain DNA, It provides physical protection to the dentine within it and helps to protect the DNA in the dentine. After the teeth, dense compact bone is the best place to look for DNA, and therefore a femur or another long bone is favored.