Large scale disaster victim identification by DNA

When a large number of victims, as a result of a large scale disaster, needs to be identified, the Dutch National Forensic Investigation Team (*Landelijk Team Forensische Opsporing* or *LTFO*) is deployed. The LTFO is a team combining staff of the Dutch police force with that of other partners (such as the Ministry of Defence and the Netherlands Forensics Institute (*NFI*)), who have joined their expertise in the fields of forensic investigation and identification of victims. LTFO experts gather data of the victims and record all of these findings. They examine the bodies, both internally and externally, and log gender, height, hair, estimated age, any pathological peculiarities and physical characteristics (nasal shape, attached or unattached earlobes, scars, tattoos, piercings and prostheses). During examination by the LTFO, samples are taken for the purpose of DNA analysis. This concerns muscle tissue, bone tissue and a dental element (molar or tooth). Where possible, dactyloscopists take fingerprints and forensic odontologists take dental X-rays and create dental records. In addition, clothing, jewellery, glasses and other personal effects of the victims found are photographed and described in great detail.

DNA identification in three steps

DNA identification can be divided into three steps:
1. obtaining DNA profiles from Ante Mortem (AM) material;
2. obtaining DNA profiles from Post Mortem (PM) material;
3. comparative DNA analysis of the DNA profiles from AM and PM materials.

1. DNA profiles from Ante Mortem (AM) material
Ante Mortem (AM) means ‘before death’. DNA identification uses two categories of AM material:
- cell material from relatives of the missing persons: preferably first-degree relatives, such as parents, children or siblings. Special authorized police officers take buccal swabs from the relatives by collecting cheek cells from inside their mouth with an applicator.
- cell material present on personal items of the missing persons: personal objects used, such as a toothbrush or razor, or a comb. In practice, such objects are not always available, and some caveats should be made. The first question is whether the object really belongs to the missing person and the second question is whether it has been exclusively used by the missing person.

DNA profiles are obtained from the AM cell material. This results in DNA profiles of the missing persons and DNA profiles of their relatives.

2. DNA profiles from Post Mortem (PM) material
Post Mortem (PM) means ‘after death’. The material concerns samples from the body or body parts of the victims. Depending on the condition of the body or body part, muscle tissue, bone tissue or a molar or tooth are used in the DNA identification process.
If no usable muscle tissue is available, molars, teeth or bone tissue are used. In molars and teeth, DNA is best protected against external influences.

DNA profiles are obtained from the PM cell material. This results in DNA profiles of the human remains.

3. Comparative DNA analysis

For the purpose of comparing the DNA profiles from the AM material and those of the PM material, the NFI uses a highly sophisticated software system. This software is specifically developed for mass disaster victim identification by DNA testing and is called Bonaparte. The name refers to Napoleon Bonaparte, who introduced the registry of births, deaths and marriages in 1811 in the Netherlands, in which everybody had to be registered with a surname. The Bonaparte software gives the victims, as it were, back their names.
The Bonaparte software was deployed in 2010 in the identification of the victims of the Tripoli plane crash (flight 771 of the Libyan Afriqiyah Airways).[1] [2]

The family trees of the missing persons and the DNA profiles of their relatives are entered into Bonaparte. Any DNA profile of a missing person available (obtained from personal items) is also entered.
The computer system places the relatives' DNA profiles and those of the missing persons in the family trees. To determine which victim belongs to which family tree, Bonaparte compares the DNA profile of each body (or body part) to the DNA profiles in the family trees. It analyses and calculates for each body (or body part) whether its DNA profile fits the DNA profiles of the missing persons' relatives. If a family tree also contains a missing person's DNA profile, Bonaparte will analyse whether there is a match between the DNA profile of a body or body part with the profile of the missing person. The software recognizes patterns of similarity in the DNA profiles. When the DNA profile of a body (or body part) fits the DNA profiles in a family tree, Bonaparte subsequently calculates the scientific evidentiary value of that resemblance.

Bonaparte also compares the DNA profiles of the bodies. That way, body parts can be linked to each other. This happens when DNA profiles of body parts match.

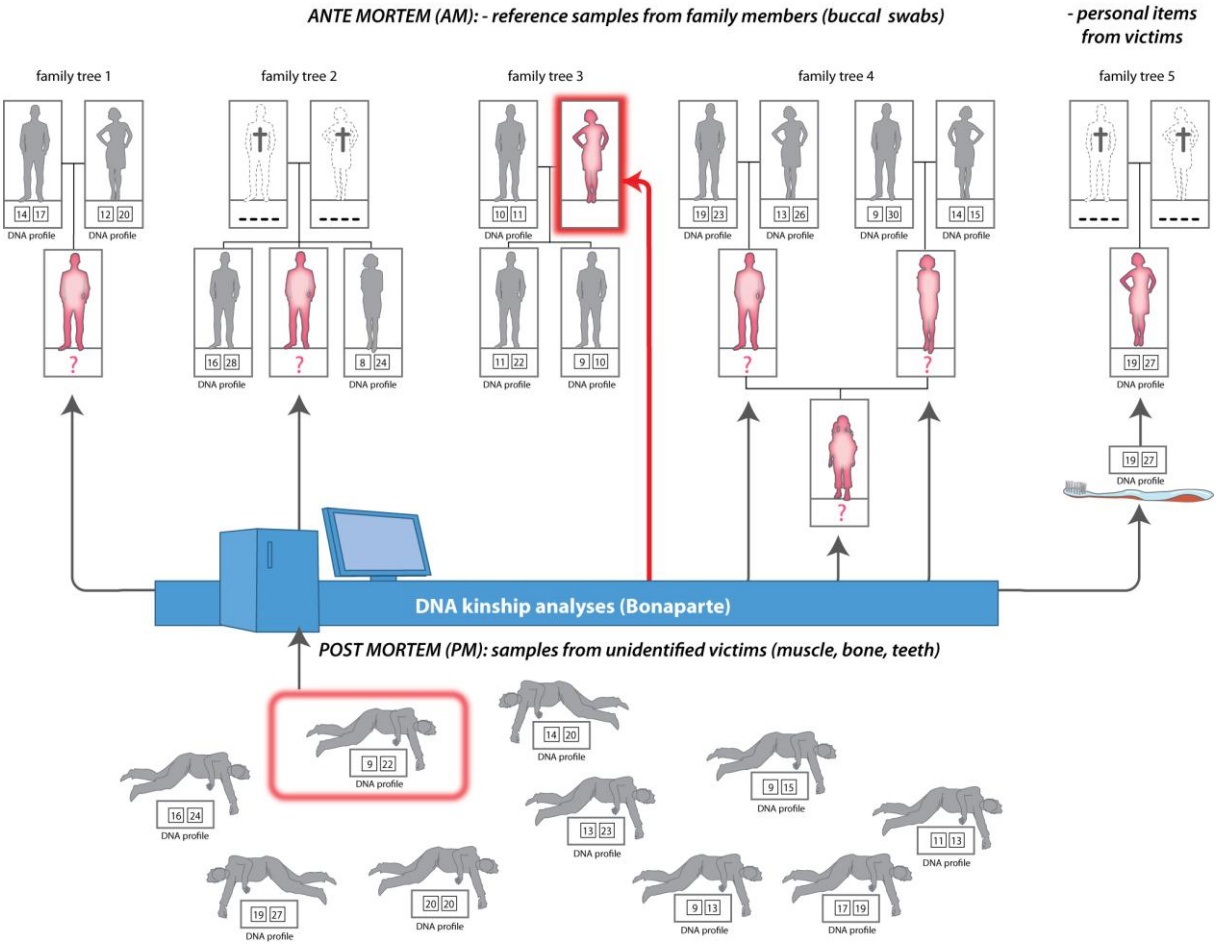
When several children in a family are missing, it is possible to determine which name belongs to which child by means of the DNA profiles obtained from the cell material found on personal objects used by those children. Otherwise, the forensic anthropologist may help identify them on the basis of an estimate of their respective age.

---

1 For more detailed information on the large-scale DNA identification process of the Tripoli crash, see chapter 20 (The Tripoli plane crash) in the book "*Kroongetuige DNA; Onzichtbaar spoor in spraakmakende zaken*", (DNA crown witness; invisible evidence in high-profile cases), A. J. Meulenbroek and P. Poley, published by De Bezige Bij (ISBN 978 90 234 8932 0).

2 Bonaparte only contains the data regarding the DNA identification process, not that of the other identification processes, such as physical characteristics, fingerprints and dental records.

The result of DNA testing is part of the ultimate identification process. Based on the coherence between all results of all different identification methods, external and internal physical examination, specific distinguishing characteristics, fingerprints, dental records and DNA profiling, the body will be identified.



The figure explained

In the figure, the DNA identification process is presented in a diagram based on five family trees of seven missing persons. To keep it simple, the DNA profiles in the figure are represented by only two markers (the two numbers in the boxes). In reality, DNA profiles consist of 30 markers (30 numbers) and gender-specific markers (whether the DNA comes from a man or a woman).

- family tree 1: the DNA profiles of both parents of the missing man are known.
- family tree 2: the missing man's parents are no longer alive. The DNA profiles of his brother and his sister are known.
- family tree 3: the DNA profiles of the missing woman's husband and their two sons are known.
- family tree 4: three persons from this family are missing: a child and both parents. The DNA profiles of the child's four grandparents are known.

- family tree 5: the missing woman's parents are no longer alive. The woman has no siblings. However, her toothbrush is available. The cell material obtained from it has resulted in a DNA profile.

The Bonaparte software compares the DNA profiles of the bodies (and body parts) to those of the relatives and of the missing persons in the family trees. The DNA profile of the victim in the red box fits the DNA profiles of the family members in family tree 3. This body has DNA markers 9 and 22. This combination only fits with individuals in family tree 3. Children inherit DNA markers from their parents. A child's DNA markers have to be found in the DNA profile of its parents. A child gets half of its genetic material from the father and the other half from the mother.

* the body with DNA markers 14 and 20 fits family tree 1. DNA marker 14 was inherited from the father in the family tree and DNA marker 20 from the mother.
* the body with DNA markers 16 and 24 fits family tree 2. These DNA markers are also found in the missing person's siblings.
* the body with DNA markers 13 and 23 and that with DNA markers 9 and 15 fit the husband and wife respectively in family tree 4. The body with DNA markers 9 and 13 fits the child in family tree 4.
* There is a match between the body with DNA markers 19 and 27 and the cell material obtained from the missing person's toothbrush in family tree 5. The cell material obtained from the toothbrush also contains DNA markers 19 and 27.