Forensic Molecular Biology

New DNA Methods Bring Skeletons Out of the Closet

Michael Gross

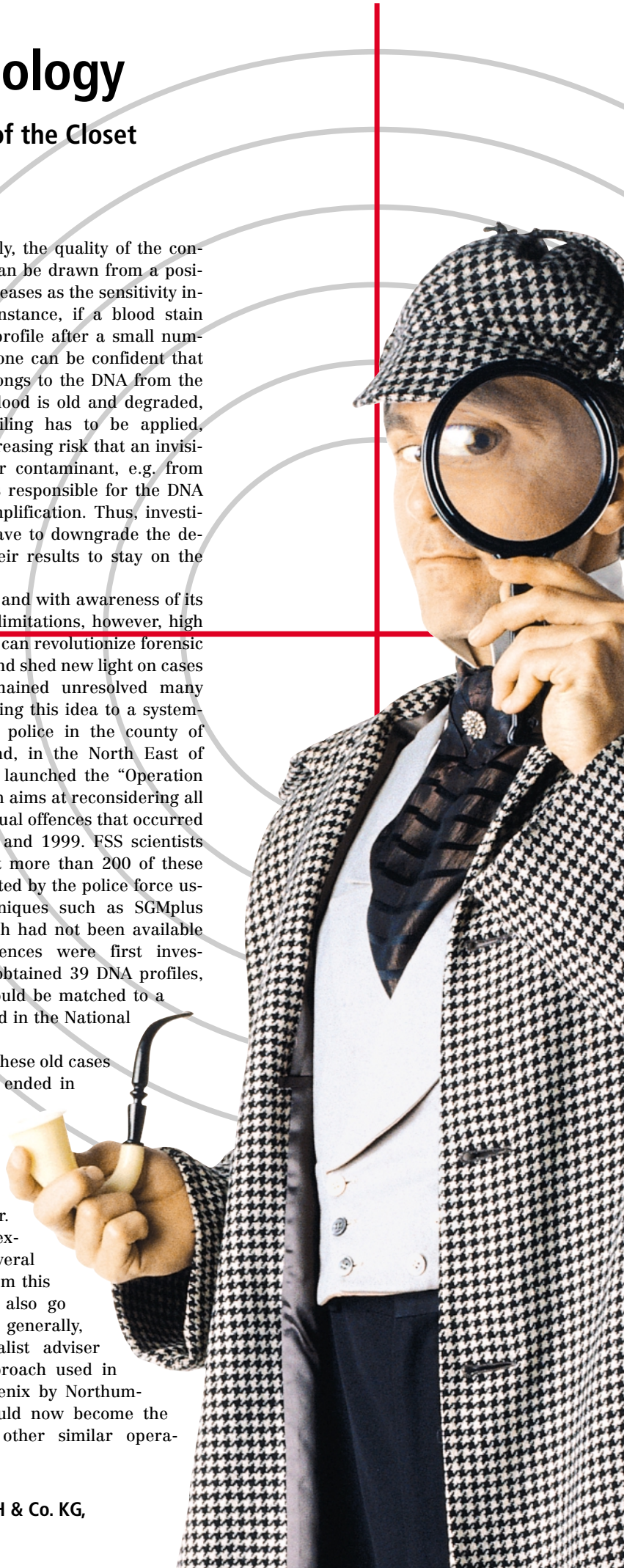
A few days before Christmas 1990, 26-year-old Geraldine Palk was brutally raped and murdered near her home in Southern Wales. The forensic experts investigating the case at the time produced DNA profiles of her attacker and compared them with samples from over 5000 men, but they were unable to find a match. In the attempt, they used up all the DNA samples available, so there appeared to be no hope left to solve the case. In 1995, the UK government set up the National DNA Database, designed to accommodate DNA profiles of all people convicted or suspected of serious crimes, but it uses different sequences from the ones in the DNA profile obtained in the Palk case. More than a decade later, however, investigators of the British Forensic Science Service (FSS, a department of the UK home office, which provides forensic services to police forces in England and Wales) revisited her case and analysed the seemingly empty plastic tube in which medical swabs had been stored. Using a new, extremely sensitive PCR approach known as Low Copy Number (LCN) analysis, they obtained a new DNA profile of the attacker. Comparing the new DNA profile against the database, the investigators identified a new suspect, who was then prosecuted and convicted in November 2002.

In principle, LCN profiling is just polymerase chain reaction (PCR) run over many cycles. However, because of the enormous power of the method to pick up even single molecule contaminants, researchers have to be extremely careful in excluding any source of contamination. Standard procedures would involve around 1 ng of DNA and up to 30 amplification cycles (i. e. billion-fold amplification). To push the procedure into the picogram range by using more than 30 cycles, one has to follow specific procedures. As Peter Gill, an LCN profiling expert at the FSS explains, increasing the cycle number too far will not result in increased sensitivity, but only encourage artefact production. Moreover, such high-sensitivity work must be conducted in a sterile laboratory. DNA profiles of all investigators must be compared to any profiles obtained.

Unfortunately, the quality of the conclusions that can be drawn from a positive result decreases as the sensitivity increases. For instance, if a blood stain yields a DNA profile after a small number of cycles, one can be confident that the profile belongs to the DNA from the blood. If the blood is old and degraded, and LCN profiling has to be applied, there is an increasing risk that an invisible but fresher contaminant, e.g. from spit droplets is responsible for the DNA found after amplification. Thus, investigators often have to downgrade the description of their results to stay on the safe side.

Used wisely and with awareness of its problems and limitations, however, high sensitivity PCR can revolutionize forensic investigation and shed new light on cases that have remained unresolved many years ago. Taking this idea to a systematic level, the police in the county of Northumberland, in the North East of England, have launched the "Operation Phoenix" which aims at reconsidering all unresolved sexual offences that occurred between 1985 and 1999. FSS scientists have looked at more than 200 of these old cases selected by the police force using DNA techniques such as SGMplus and LCN, which had not been available when the offences were first investigated. They obtained 39 DNA profiles, of which 19 could be matched to a person included in the National DNA Database.

The first of these old cases going to court ended in January this year with a conviction for a rape committed seven years earlier. FSS sources expect that several other cases from this operation will also go to court. More generally, an FSS specialist adviser says, "the approach used in Operation Phoenix by Northumbria Police could now become the blueprint for other similar operations."



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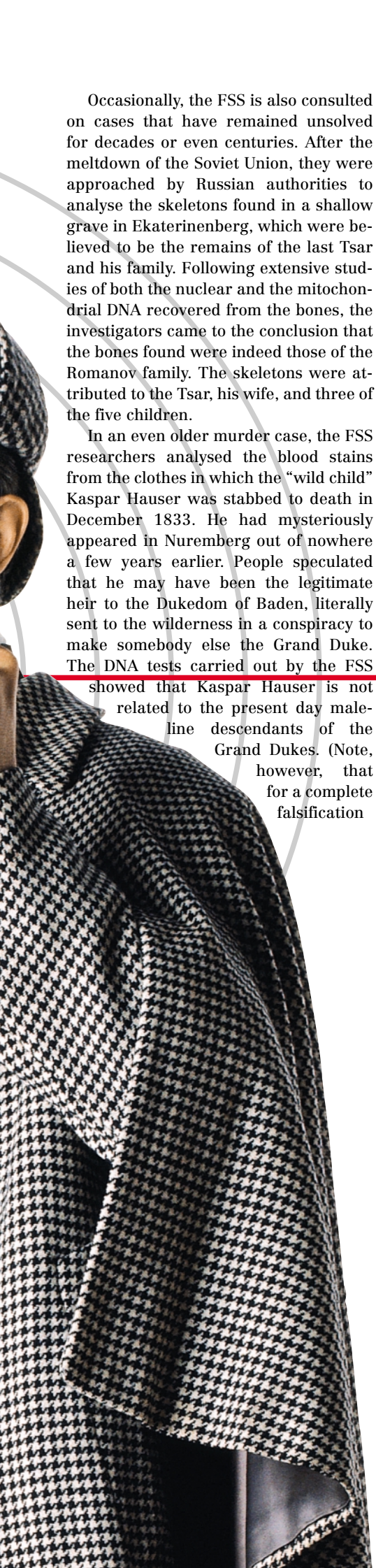

Occasionally, the FSS is also consulted on cases that have remained unsolved for decades or even centuries. After the meltdown of the Soviet Union, they were approached by Russian authorities to analyse the skeletons found in a shallow grave in Ekaterinenberg, which were believed to be the remains of the last Tsar and his family. Following extensive studies of both the nuclear and the mitochondrial DNA recovered from the bones, the investigators came to the conclusion that the bones found were indeed those of the Romanov family. The skeletons were attributed to the Tsar, his wife, and three of the five children.

In an even older murder case, the FSS researchers analysed the blood stains from the clothes in which the "wild child" Kaspar Hauser was stabbed to death in December 1833. He had mysteriously appeared in Nuremberg out of nowhere a few years earlier. People speculated that he may have been the legitimate heir to the Dukedom of Baden, literally sent to the wilderness in a conspiracy to make somebody else the Grand Duke. The DNA tests carried out by the FSS showed that Kaspar Hauser is not related to the present day male-line descendants of the Grand Dukes. (Note, however, that for a complete falsification of the original claim, one would also have to scientifically prove that the male line has been reported truthfully.)

Back in the present day, while the double helix makes up much of the evidence that forensic scientists look at nowadays, there are also cases where a lack of useful DNA evidence forces them to turn to other materials, such as textile fibres. This happened in the case of the murdered schoolgirl Sarah Payne, which rocked Britain in 2000 and led to a wave of vigilante action and violent attacks against "suspected pedophiles" (in one case an obviously illiterate mob attacked a pediatrician instead!). While DNA evidence was important for the identification of the victim, the crucial evidence leading to her killer came from the velcro fastening of Sarah's shoe which had trapped 350 fibres. Investigating these one by one under a microscope, investigators could attribute some of them to Sarah's clothing, and others to items of clothing found in the suspect's car. In this case, there was no DNA evidence leading to the attacker, but a conviction was secured based on the analysis of the fibres.

Forensic work has the intrinsic disadvantage that it only starts when it is too late and somebody has been killed or grievously harmed. However, considering that in the days of PCR a single hair is sufficient evidence to link a suspect to a crime, people with murder on their mind should be aware that they are much more likely to be caught than they were only a decade ago. The widespread interest in forensics-based TV shows such as CSI: Crime Scene Investigation might help to spread the word. Such that in the long term, molecular biology and other scientific methods used in forensic analysis might help to make our world a safer place to live in.

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