My 'DNA fingerprinting, Genetics, and Ethics' lecture to honour Haldane's memory

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J B S Haldane (1892–1964), the distinguished British-Indian geneticist and evolutionary biologist, willed that after his death his body be used for medical education and research. Accordingly, the Rangaraya Medical College (RMC), Kakinada, prepared his skeleton and organs for display in their Haldane Museum, to enable viewing by medical students and others. In December 2025, on the occasion of Haldane's 133 birth anniversary celebration, the RMC invited me to deliver a lecture. This was a rare opportunity to visit the museum and pay my tribute to the great scientist's memory. I accepted with alacrity.

Between 2012 and 2017 I was privileged to hold the Haldane Chair (HC) at the Centre for DNA Fingerprinting and Diagnostics (CDFD), in Hyderabad. Aside from doing research in fungal genetics, I served as 'an extra pair of eyes' to examine DNA reports before they went up to the Director for final signature. Subsequently, I continued in the latter role, first as an INSA Senior Scientist, and now as an INSA Honorary Scientist. I must have examined over 2000 reports.

Four reports stood out in my mind. They provoked questions pertaining to crime investigation, privacy, the law and societal mores, and whether DNA scientists, police, and judges are knowledgeable enough in diverse areas such as probability and statistics, chimeras in humans, and communities that practice levirate marriage.

Given my expertise, the HC connection, and likely audience, 'DNA fingerprints raise ethics questions in a geneticist's mind' became the topic for my lecture. Accordingly, I titled it 'DNA fingerprinting, Genetics, and Ethics'.

STR loci and DNA fingerprints

DNA fingerprinting involves resolving different sized alleles at STR (short tandem repeat) loci in an individual's genome. An STR is made up of a short sequence of DNA base pairs repeated a number of times. For example, it could consist of four repeats of the bases GATC on one DNA strand. This would look like: 'GATCGATCGATCGATC'. The complementary strand would have the base sequence 'CTAGCTAGCTAGCTAG'. The human genome has over a million STR loci. Many are quite polymorphic, with repeat numbers varying over a wide range of values. And the paternally- and maternally-derived alleles need not have the same repeat number. Unrelated individuals almost certainly have different repeat numbers in at least some STRs. A DNA fingerprint, also called a DNA profile, is a table listing a pair of numbers representing the allele sizes at about 16 to 30 STRs.

The four cases

One case was a plain vanilla kind, showing a couple were a child's parents (figure 1). Another exposed a father-daughter incestuous rape (figure 2). The third (figure 3) was related to a sexual assault case in which the suspect did not father the victim's baby. And the fourth (figure 4) pertained to an organ transplantation case. The donor and recipient were confirmed to be related, enabling doctors to proceed with the procedure. But the DNA showed they were not father and son as claimed, but uncle and nephew. This raised the possibility that the donor might be a chimera.
A chimera is an individual with cells derived from two different zygotes. The sperm cell responsible for conceiving his son could have had a different genome than his peripheral blood cells used in the paternity test.

Another possibility was that the son was the product of a levirate marriage. A levirate marriage is one in which a woman who is widowed, or one whose husband is mentally or physically incapacitated, has children fathered by her husband's brother.

Some of the cases were previously described
(https://www.ias.ac.in/public/Resources/Articles_Repository/chimeras.pdf ;
https://dialogue.ias.ac.in/index.php/dialogue/article/view/100).

Question 1 – Is it reasonable to suspect incest based on a DNA profile?

Geneticists are taught to calculate the probability (F) that an individual inherits the same allele of any locus from both parents. F also represents the fraction of an individual's genome that is likely homozygous (that is, the paternally- and maternally-inherited versions are indistinguishable). In an embryo from a father-daughter, mother-son, or brother-sister incestuous mating F = ¼.

In figure 2 (pertaining to the father-daughter rape), the baby was indeed homozygous at 4 of the 15 genetic loci examined. (One STR distinguished the X and Y chromosomes.) But the baby's father and grand-mother also were homozygous at 4 of the 15 loci. Is is quite unlikely that they too were products of incest. The child in figure 1 (from a non-incestuous marriage) also was homozygous at 4 of 15 loci. Clearly, although children born out of incest are expected to be homozygous at ¼ of their loci, most homozygotes at ¼ of the loci are not the products of incest.

Figure 3 shows the alleged perpetrator of a sexual assault did not father the victim's baby. He did not carry many of the baby's paternally-derived alleles (red font). Based on this, the examiners correctly excluded him as the baby's father.

The baby was, however, homozygous at more than 50% of its loci, greatly exceeding the expectation from incestuous mating. Could the actual perpetrator have been the victim's father or brother? This question can be answered only by examining their DNA. Does the high fraction give sufficient probable cause to demand that the victim's father and brother submit to a DNA test? How much more than 25% counts as a significant excess? How about in a sexual assault case such as this in which the victim, possibly out of fear, misidentified the real perpetrator?

Courts and police insist that DNA reports should only answer the question asked, and nothing more. In this instance whether the alleged perpetrator fathered the victim's baby. Any additional speculation that the actual perpetrator might be her father or brother is unwelcome. Won't this affect justice delivery?

Haldane famously joked that he would willingly risk his life to save two brothers, or eight cousins. The joke illustrated his penchant for calculating risks and individual relatedness. He would be surprised that we still don't know what represents a significant deviation from a mean value of F. Embarrassingly, in spite of the fact that millions of whole genome sequences are now available we do not know the mean, median, or modal fraction of homozygous STRs in any population.

Question 2 – Can scientific curiosity trump a family's privacy?

The DNA fingerprints in figure 4 showed the organ donor was not the recipient's father, but possibly an uncle, given that he shared the same Y chromosome and several shared alleles (black font). We do not know how frequently chimeras occur in Indian populations. We also do not know their medical consequences. Therefore, finding one could be of medical significance. But to establish chimerism we would first have to rule out the possibility of levirate marriage. This can only be done by interviewing the family to enquire whether the patient's mother's brother-in-law could have been his father. Such an interview would obviously breach the family's privacy.

The case was included to teach the students that respecting a family's privacy and dignity trumps fulfilling one's scientific curiosity. JBS would have approved the lesson.

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Figure 1. DNA profiles of a mother-child-father trio. Homozygous alleles are highlighted.

Locus	Trio		
	Mother	Child	Father
D3S1358	16, 17	16,17	16, 17
TH01	8, 9	8, 9	9, 9.3
D21S11	28, 31.2	28, 28	28, 28
D18S51	14, 17	13, 17	12, 13
Penta E	11, 12	10, 11	10, 17
D5S818	9, 10	9, 13	11, 13
D13S317	11, 14	8, 14	8, 13
D7S820	8, 11	11, 11	11, 12
D16S539	10, 13	10, 11	11, 11
CSF1PO	10, 11	11, 13	12, 13
Penta D	9, 9	9, 9	9, 13
VWA	15, 18	18, 19	18, 19
D8S1179	13, 15	8, 13	8, 13
TPOX	8, 8	8, 11	10, 11
FGA	22, 22	22, 22	20, 22
Amelogenin	X, X	X, Y	X, Y

Figure 2. DNA profiles establish a father-daughter incest. Homozygous alleles are highlighted.

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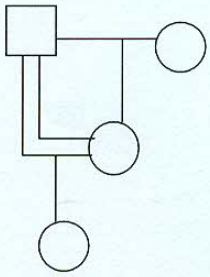
TABLE-I

GENOTYPE ANALYSIS FOR ESTABLISHING PATERNITY USING MICROSATELLITES i) D2S1338 ii) D16S539 iii) D13S317 iv) TH01 v) D3S1358 vi) D18S51 vii) TPOX viii) vWA ix) D19S433 x) CSF1PO xi) D7S820 xii) D21S11 xiii) D8S1179 xiv) FGA xv) D5S818 and xvi) Amelogenin



Locus	Sample Nos.			
	5187 Exhibit A (Victim)	5188 Exhibit B (Baby of victim)	5189 Exhibit C (Alleged Father)	5233 Exhibit D (Mother of victim)
D2S1338	23, 25	23, 19	19, 25	18, 23
D16S539	11, 11	11, 11	11, 11	11, 12
D13S317	9, 11	11, 9	9, 12	8, 11
TH01	6, 8	8, 8	8, 9	6, 6
D3S1358	16, 17	16, 17	17, 17	16, 19
D18S51	14, 15	14, 15	14, 15	14, 14
TPOX	8, 9	9, 8	8, 11	9, 11
vWA	16, 17	17, 18	17, 18	16, 16
D19S433	13, 14	13, 14	14, 14	13, 15
CSF1PO	11, 11	11, 12	11, 12	9, 11
D7S820	10, 10	10, 10	10, 11	10, 11
D21S11	31.2, 33.2	31.2, 33.2	31.2, 33.2	31.2, 31.2
D8S1179	10, 12	10, 16	10, 15	12, 13
FGA	20, 24	24, 25	20, 25	24, 25
D5S818	11, 13	11, 11	11, 11	11, 13
Amelogenin	X, X	X, X	X, Y	X, X

Figure 3. DNA profiles from a sexual assault case. Homozygous alleles are highlighted. Red font indicates alleles in the baby missing from the suspect.

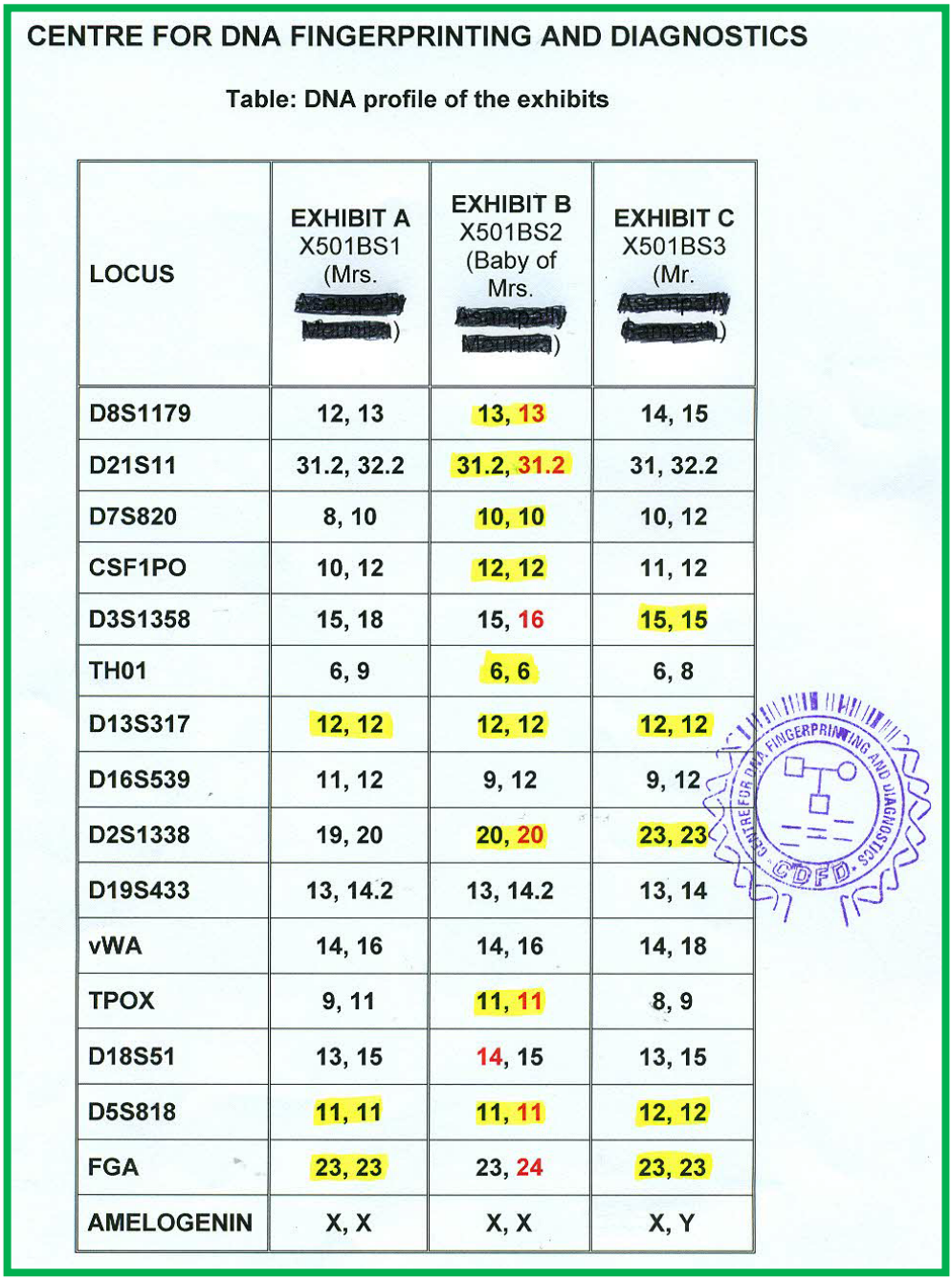


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Table: DNA profile of the exhibits

LOCUS	EXHIBIT A X501BS1 (Mrs. [redacted])	EXHIBIT B X501BS2 (Baby of Mrs. [redacted])	EXHIBIT C X501BS3 (Mr. [redacted])
D8S1179	12, 13	13, 13	14, 15
D21S11	31.2, 32.2	31.2, 31.2	31, 32.2
D7S820	8, 10	10, 10	10, 12
CSF1PO	10, 12	12, 12	11, 12
D3S1358	15, 18	15, 16	15, 15
TH01	6, 9	6, 6	6, 8
D13S317	12, 12	12, 12	12, 12
D16S539	11, 12	9, 12	9, 12
D2S1338	19, 20	20, 20	23, 23
D19S433	13, 14.2	13, 14.2	13, 14
vWA	14, 16	14, 16	14, 18
TPOX	9, 11	11, 11	8, 9
D18S51	13, 15	14, 15	13, 15
D5S818	11, 11	11, 11	12, 12
FGA	23, 23	23, 24	23, 23
AMELOGENIN	X, X	X, X	X, Y

Figure 4. The organ donor case. Green font indicates the patient's mother, blue font the donor, black and red fonts the patient's father. Alleles in red font are absent from the donor.

Table: Autosomal and Y-chromosomal STR DNA profiles of the exhibits

Locus	Exhibit C	Exhibit A	Exhibit B
	Link Person	Patient	Donor
	X1154 B3	X1154 B1	X1154B2
D3S1358	16,16	16,16	15,18
vWA	14,17	14,14	15,18
D16S539	11,12	11,12	11,12
CSF1PO	10,13	12,13	11,12
TPOX	8,11	8,11	8,11
Yindel	-	2	2
D8S1179	13,14	14,15	13,15
D21S11	29,33.2	29,33.2	28,32.2
D18S51	14,15	15,17	14,14
DYS391	-	10	10
D2S441	9,10	10,10	10,11
D19S433	13,13	13,13	13,13
TH01	7,8	7,9	6,9
FGA	24,24	24,27	23,27
D22S1045	11,17	11,17	11,17

D5S818	10,12	12,15	12,15
D13S317	8,12	12,12	11,12
D7S820	8,12	11,12	11,13
SE33	13,29.2	13,29.2	19,29.2
D10S1248	13,15	14,15	14,14
D1S1656	14,14	14,17.3	8,15.3
D12S391	21,24	17,21	17,17.3
D2S1338	19,22	21,22	19,21
AMELOGENIN	X,X	X,Y	X,Y
Locus	Exhibit A	Exhibit B	
	Patient	Donor	
	X1154 B1	X1154B2	
DYS576	17	17	
DYS389I	13	13	
DYS635	23	23	
DYS389II	29	29	
DYS627	19	19	
DYS460	10	10	
DYS458	16	16	
DYS19	14	14	
YGATAH4	11	11	

DYS448	21	21
DYS391	10	10
DYS456	17	17
DYS390	23	23
DYS438	9	9
DYS392	11	11
DYS518	40	40
DYS570	16	16
DYS437	14	14
DYS385	12,16	12,16
DYS449	31	31
DYS393	12	12
DYS439	11	11
DYS481	23	23
DYF387S1	36,39	36,39
DYS533	11	11