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by

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Essay

Chimeric Criminals

David H. Kaye*

ABSTRACT

According to some commentators, an obscure genetic condition known as chimerism “could undermine the very basis of the forensic DNA system” and force a reconsideration of “the entire project of forensic DNA.” This conclusion is as unfounded as it is unnerving. Chimerism is a consideration in, but not a real obstacle to DNA identification. This essay explains why.

CHIMERIC CRIMINALS

Several commentators have speculated about the importance of an obscure genetic condition known as chimerism for DNA identification.¹ The most extreme views appear in a

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1. SHELDON KRIMSKY & TANYA SIMONCELLI, GENETIC JUSTICE: DNA DATABANKS, CRIMINAL INVESTIGATIONS, AND CIVIL LIBERTIES 301–04 (2011); Catherine Arcabascio, *Chimeras: Double the DNA—Double the Fun for Crime Scene Investigators, Prosecutors, and Defense Attorneys?*, 40 AKRON L. REV. 435, 454 (2007) (“The DNA sky is not falling upon the criminal justice system simply because chimerism exists. However . . . chimerism could, in theory, impact criminal cases . . .”); Erin Murphy, *A Tale of Two Sciences*, 112 MICH. L. REV. 909, 916 (2012) (“[W]e simply cannot know how much to make of these illustrations [of chimerism and other threats to accuracy in DNA testing because] the government is largely responsible for our ignorance, due to its refusal to act more transparently with regard to the development and use of DNA methods.”); Emily Holland, Comment, *Moving the Virtual Border to the Cellular Level: Mandatory DNA Testing and the U.S. Refugee Family Reunification Program*, 99 CAL. L. REV. 1635, 1662 n.186 (2011) (“unusual case”);

recent book, *Genetic Justice: DNA Databanks, Criminal Investigations, and Civil Liberties*.² As part of “a stream of measured arguments”³ that supposedly supplies “a deeper and more balanced appreciation of the issues”⁴ and an “inspiring yet realistic vision,”⁵ Sheldon Krinsky⁶ and Tania Simoncelli⁷ state that an obscure genetic condition known as chimerism “could undermine the very basis of the forensic DNA system” and force a reconsideration of “the entire project of forensic DNA.”⁸ This claim is as baseless as it is breathless. Chimerism is a consideration in, but not a major obstacle to, DNA identification. This essay explains why.

I. THE CONCERN ABOUT CHIMERAS

In Greek mythology, a chimera is the offspring of Typhon and Echidna, and a sibling of the three-headed monster, Cerberus.⁹ With the parts of a lion, a goat, and a dragon, the chi-

Tera Rica Murdock, Note, *Whose Child Is This?: Genetic Analysis and Family Reunification Immigration in France*, 41 VAND. J. TRANSNAT'L L. 1503, 1522–23 (2008) (suggesting that the majority of people are chimeras).

2. KRIMSKY & SIMONCELLI, *supra* note 1.

3. Murphy, *supra* note 1, at 911. *But see id.* at 916 (conceding that the book’s fears, might be “mostly speculative or hypothetical”).

4. Anthony D. Romero, *Foreword* to KRIMSKY & SIMONCELLI, *supra* note 1, at viii (2011).

5. *Genetic Justice: DNA Data Banks, Criminal Investigations, and Civil Liberties*, AMAZON.COM, http://www.amazon.com/dp/0231145217/ref=rdr_ext_tmb (last visited Oct. 21, 2012) (citing the book’s promotional information).

6. Dr. Krinsky is a professor of urban planning and environmental policy and the chairman of an advocacy organization known as the Council for Responsible Genetics. *See Board of Directors and Emeriti*, COUNCIL FOR RESPONSIBLE GENETICS, <http://www.councilforresponsiblegenetics.org/Help/Directors.aspx> (last visited Nov. 6, 2012).

7. Ms. Simoncelli is a member of the board of the Council for Responsible Genetics and a former science adviser to the ACLU. *See CLB Speaker Series: Tania Simoncelli (ACLU)*, STAN. L. SCH., <https://www.law.stanford.edu/event/2007/11/07/clb-speaker-series-tania-simoncelli-aclu> (last visited Sept. 28, 2012).

8. KRIMSKY & SIMONCELLI, *supra* note 1, at 303.

9. *Chimera (mythology)*, PRINCETON U., http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Chimera_%28mythology%29.html (last visited Nov. 6, 2012).

mera is a powerful and hideous beast.¹⁰ In genetics, “chimerism” is nothing like this. It is simply “the presence of two genetically distinct cell lines in an organism.”¹¹ Such chimerism can be temporary, occurring after a blood transfusion, for example, or permanent, resulting from progenitor cells with different genomes dividing to generate different cell lines.¹²

According to *Genetic Justice*, chimerism could well be commonplace in the general population.¹³ Krinsky and Simoncelli quote estimates of 1 in 2400, 1 in 10, 1 in 8, and even 1 in 1 for the incidence of chimerism.¹⁴ They conclude that “[i]f chimerism occurs at a higher rate than the lower estimates predict, the entire project of forensic DNA would have to be reconsidered for fallibility of identification” and that “[t]he possibility that chimeras are a rule rather than a rare exception could undermine the very basis of the forensic DNA system.”¹⁵ To see their point, imagine a rapist whose semen comes from one cell line but whose buccal epithelial cells—the ones scrapped off when swabbing the inside of the cheek to acquire a reference sample¹⁶—represent a different cell line. This man always would slip through the net of DNA matching. Indeed, he would be positively excluded if his profile were in a law enforcement DNA database or if he provided a reference sample voluntarily (or otherwise).

Should the police therefore worry that a suspect whose DNA does not match a crime-scene sample is a chimera? Should we rethink some of the hundreds of DNA exonerations that have proved so important in pinpointing sources of error in the criminal justice system?¹⁷ Could it be that many of the ex-

10. THOMAS BULFINCH, *THE AGE OF FABLE* (1855), reprinted in *BULFINCH'S MYTHOLOGY* 3, 117–18 (Random House 1993); see also Arcabascio, *supra* note 1, at 436–38 (2007) (restating the mythology of the chimera); Henry T. Greely, *Defining Chimeras . . . and Chimeric Concerns*, *AM. J. BIOETHICS*, Summer 2003, at 17 (“The original chimera turns out to be surprisingly undefined. Did Bellerophon, riding Pegasus, slay a monster with the heads of three different species or a one-headed beast with parts from three species?”).

11. Neng Yu et al., *Disputed Maternity Testing Leading to Identification of Tetragametic Chimerism*, 346 *NEW ENG. J. MED.* 1545, 1545 (2002).

12. *See id.*

13. KRIMSKY & SIMONCELLI, *supra* note 1, at 301–04.

14. *Id.* at 302.

15. *Id.* at 303.

16. *See Buccal Swab Sample Collection Kit Procedures*, TEX. DEP'T PUB. SAFETY, <http://www.txdps.state.tx.us/CrimeLaboratory/CODIS/BuccalSwab.htm> (last visited Oct. 21, 2012).

17. BRANDON L. GARRETT, *CONVICING THE INNOCENT: WHERE CRIMINAL*

onerees are “[c]riminal chimeras” who have been “mistakenly exonerated”?¹⁸ To assess these possibilities, we need to understand that there are various types and causes of chimerism.¹⁹ One or two types sometimes could create rare problems in forensic identification, but lumping together all forms and degrees of chimerism and then proposing that DNA identification might be untrustworthy because the totality of cases of chimerism might be large is fallacious.²⁰ It equates a broad category of situations with a far smaller set that requires special treatment.

II. MICROCHIMERIC CRIMINALS

To understand why it is misleading to combine all cases of chimerism, let us assume that, at a sufficient level of detail, we are all chimeras. Perhaps a few of my mother’s cells became part of me (or the proto-me) that was a fetus. Maybe I shared her womb briefly with an unknown fraternal twin who passed some cells to me before that fetus or embryo was absorbed by my mother. If so, it is possible that elaborate genetic testing of enough different tissues in my body could detect their progeny along with my predominant genome.

But what effect could this have on forensic testing? If a few cells of my liver or my brain had the foreign genome, the DNA from these cells would never be detected in a forensic test of the cells from a buccal swab used to ascertain my DNA profile or in a test of the cells in bodily fluids found on victims or at crime scenes. Moreover, even if a few cells were in the tissues that are of forensic significance, they would be undetectable or would produce such small peaks in an electropherogram that no analyst would consider them part of a profile.²¹ Consequently, chimerism could be ubiquitous—and irrelevant to forensic

PROSECUTIONS GO WRONG 5–6 (2011) (listing statistics for DNA exonerations).

18. KRIMSKY & SIMONCELLI, *supra* note 1, at 303 (implying that criminal chimeras exist).

19. *See* Greely, *supra* note 10, at 18.

20. *See* Arcabascio, *supra* note 1, at 457.

21. William C. Thompson et al., *Part 1: Evaluating Forensic DNA Evidence: Essential Elements of a Competent Defense Review*, CHAMPION, Apr. 2003, at 19.

testing.

In fact, the transfer of blood between mother and fetus or between twins does produce cases of “microchimerism” with surprising frequency.²² But even in the unlikely event that ordinary forensic testing would detect the foreign blood cells, the result would not be a false exclusion. The sample would show extra alleles, just as any other mixture that includes the suspect’s major strain of DNA might.²³ Thus, although analysts need to be aware of chimerism as a possible explanation for apparent mixtures, it is not clear that congenital blood chimerism has the dramatic “implications for paternity testing and forensic analysis”²⁴ that Krimsky, Simoncelli, and other commentators seem to attribute to all chimerism.

III. ACQUIRED CHIMERISM: BLOOD TRANSFUSIONS AND BONE MARROW TRANSPLANTATION

Blood transfusions certainly produce short-term chimerism, but it should not produce exclusions.²⁵ If the reference sample is blood after a transfusion, it obviously will be a mixture.²⁶ If the trace evidence also is blood, then both mixtures should match. Not only will the transfused criminal be included as a possible suspect, but the association will be especially powerful because the chance of an innocent person also being a chimera carrying around precisely the same double DNA types is infinitesimal.²⁷ If the trace sample is epithelial cells, hair, or semen from the transfused criminal, then the blood reference

22. J. Lee Nelson et al., *Microchimerism and HLA-Compatible Relationships of Pregnancy in Scleroderma*, 351 LANCET 559, 559 (1998); see also Kristina M. Adams & J. Lee Nelson, *Microchimerism: An Investigative Frontier in Autoimmunity and Transplantation*, 291 JAMA 1127, 1128–29 (2004) (describing fetal microchimerism in autoimmune diseases); J. Lee Nelson, *Microchimerism: Incidental Byproduct of Pregnancy or Active Participant in Human Health?*, 8 TRENDS MOLECULAR MED. 109, 109–10 (2002) (discussing studies of microchimerism during pregnancy).

23. See *Chimeras, Mosaics, and Other Fun Stuff: How Is a Paternity Test Affected If the Child Is a Chimera?*, TECH MUSEUM (Nov. 17, 2011), <http://genetics.thetech.org/ask/ask443>.

24. KRIMSKY & SIMONCELLI, *supra* note 1, at 303.

25. See Azita Alizadeh, *Chimeras, Mosaics, and Other Fun Stuff*, TECH MUSEUM (Feb. 9, 2007), <http://genetics.thetech.org/ask/ask208>; see also Kristina M. Adams & J. Lee Nelson, *Microchimerism: An Investigative Frontier in Autoimmunity and Transplantation*, 291 JAMA 1127, 1130 (2004).

26. See Arcabascio, *supra* note 1, at 438.

27. See Alizadeh, *supra* note 25 (explaining that checking both blood and cheek samples might resolve differences from testing only one source).

sample should show a mixed profile including the trace profile.²⁸ Again, the temporary chimera would not be excluded.

Complete bone marrow replacement, on the other hand, would result in an individual whose blood cells have the donor's DNA type and whose other tissues continue to have his own type.²⁹ Police encountered such a person in a sexual assault investigation in Alaska in 2005.³⁰ DNA from semen matched a blood sample in the criminal data bank.³¹ Yet, this person was in jail when the assault took place, and police already had matched the semen DNA to their prime suspect.³² The two men were brothers, and the one in jail had received bone marrow from the other years earlier.³³ As one would expect, a cheek swab excluded the jailed bone marrow recipient.³⁴ Such cases obviously are exceptional, and more recent bone marrow transplant patients may receive lower doses of chemotherapy and radiation that do not kill all their bone marrow cells.³⁵ Their blood DNA profile will be a mixture from both the donor and recipient, further reducing the chance of false exclusions.³⁶

IV. TETRAGAMETIC CRIMINALS

Another type of chimerism could produce the worrisome kind of "chimeric criminals" that *Genetic Justice* discusses.³⁷ It

28. *See id.*

29. *Id.*; *see also* Arcabascio, *supra* note 1, at 439 ("In the case of a bone marrow transplant, a successful transplant patient will have a mixture of his own blood and that of the donor."). Transplanted stem cells also can contribute to the DNA profiles of other tissues. *See, e.g.*, Renata Jacewicz et al., *Genetic Investigation of Biological Materials from Patients After Stem Cell Transplantation Based on Autosomal as well as Y-Chromosomal Markers*, INT'L J. LEGAL MED. (forthcoming).

30. Peter Aldous, *Bone Marrow Donors Risk DNA Identity Mix-up*, NEW SCIENTIST, Oct. 29, 2005, at 11.

31. *Id.*

32. *Id.*

33. *Id.*

34. *Id.*

35. Alizadeh, *supra* note 25.

36. *Id.* *See* Jacewicz et al., *supra* note 29 (finding that "autosomal DNA revealed 100% of the recipient's profile" in blood, buccal swabs, and hair follicles, but cautioning that "the biological stains gathered from crime scenes should not be analysed exclusively [with] Y-chromosome markers.").

37. KRIMSKY & SIMONCELLI, *supra* note 1, at 301-02.

is called tetragametic because the individual fetus develops *in utero* not from the normal two sex cells—the mother’s egg cell fertilized by the father’s sperm cell—but from four sex cells.³⁸ As one group of researchers explains:

[T]etragametic chimerism . . . occurs through the fertilization of two ova by two spermatozoa, followed by the fusion of the zygotes and the development of an organism with intermingled cell lines. Examples have been found in mice and other mammalian species, including humans. Affected persons are identified by the finding of two populations of red cells or ambiguous genitalia and hermaphroditism, alone or in combination; such persons sometimes also have patchy skin or eye pigmentation.³⁹

The very early fusion of twins is less common than microchimerism.⁴⁰ Even rarer are cases in which the individual—who might grow up to become a “chimeric criminal”—is phenotypically normal.⁴¹ In 2002, however, physicians reported such a person after tissue-typing the family of a 52-year-old woman who needed a kidney transplant.⁴² The patient, it seemed from the HLA typing, could not be the biological mother of two of her three children.⁴³ Extensive testing established that her blood was entirely one cell line, while other tissues, including the buccal epithelium, skin, and hair were a mixture of two cell lines.⁴⁴

A legal case of tetragenic chimerism arose a year later. In 2003, “Lydia Fairchild, a mother of three who was pregnant with her fourth child, [applied] for public assistance in the state of Washington.”⁴⁵ The analysis of DNA samples for paternity tests unexpectedly showed that she was not the biological mother of the three children.⁴⁶ Not only was Fairchild denied public assistance, but she was “accused of attempting to defraud the government.”⁴⁷ However, the court appointed a witness to be present at the fourth birth.⁴⁸ Blood samples were

38. Yu et al., *supra* note 11, at 1545.

39. *Id.* (citations omitted).

40. *Id.*

41. *Id.* at 1550 (referring to the “unusual example of tetragametic chimerism in a phenotypically normal, fertile XX/XX female who had no evidence of chimerism in peripheral blood”).

42. *Id.* at 1545.

43. *Id.*

44. *Id.* at 1550–51.

45. Arcabascio, *supra* note 1, at 450.

46. *Id.*

47. *Id.*

48. *Id.* at 451.

taken, and once again, parentage testing indicated that Fairchild “was not the mother of the fourth child.”⁴⁹ Now the prosecutor hypothesized that she might have been a surrogate mother carrying another woman’s implanted embryo.⁵⁰ Fairchild’s lawyer, who had learned of the case of a tetragametic transplant patient, requested further DNA testing.⁵¹ “The DNA found in Ms. Fairchild’s skin, hair, and saliva did not match her children’s, but a sample taken from her cervical smear did match theirs. Ms. Fairchild was yet another chimera.”⁵²

Thus, some cases of tetragametic chimerism do show that “it is possible in theory for DNA testing from different tissues of a chimeric individual to not match one another and thus lead to a false exclusion.”⁵³ So the question for forensics is how common it would be (1) for an individual to have a single cell line in one tissue of forensic interest (such as blood or semen that could be left at a crime scene), but (2) not to have the same cell line in a buccal swab that would provide reference DNA. Even the kidney transplant patient who was the subject of the remarkable case report in the *New England Journal of Medicine* does not fall into this category, since her epithelial cells showed both cell lines.⁵⁴ Had she been a criminal suspect, a buccal swab would have revealed both cell lines, making it impossible to exclude her as a suspect.

The suggestion that tetragametic chimerism, let alone the subclass of it described above, could occur in nearly 100% of the population is frivolous. Hundreds of thousands of paternity tests are performed every year.⁵⁵ If tetragametic chimerism were common, many exclusions of mothers would be occurring, and many instances of extra alleles in the men, women, and

49. *Id.*

50. *Id.*

51. *See id.* at 448, 451.

52. *Id.* at 451.

53. JOHN M. BUTLER, FUNDAMENTALS OF FORENSIC DNA TYPING 410 (2009).

54. *See supra* notes 38–44 and accompanying text.

55. AM. ASSOC. OF BLOOD BANKS, ANNUAL REPORT SUMMARY FOR TESTING IN 2004 3 (2005) (“The reported volume of cases tested in 2004 was 390,928.”).

children who are tested would be appearing. They are not.⁵⁶ A geneticist at Stanford University noted that:

If the DNA testing company has experience with this sort of thing, they'll be able to recognize that the sample is either contaminated or comes from some sort of chimera. One company I spoke with said they had had two chimeras so far and were able to tell the paternity.⁵⁷

The fact that forensic science conferences and journals devote time and space to the occasional reports of tetragametic chimerism also suggests that these cases are rarities.⁵⁸

In short, considering the nature and types of chimerism and the implications of each type for forensic identity testing, it should be clear that the fears raised about chimerism are exaggerated. Even if all "chimeras are a rule rather than a rare exception," it would be false to conclude that "the very basis of the forensic DNA system" would be in danger.⁵⁹ Chimerism of various types is real enough, but chimerism is not a general obstacle to parentage or identity testing.⁶⁰ Forensic analysts need to understand its possible effects, but the prospect of a horde of tetragametic criminals does not warrant reconsideration of the entire project of forensic DNA. The prospect, one might say, is itself chimerical.

56. See *Chimeras, Mosaics, and Other Fun Stuff: How Is a Paternity Test Affected if the Child Is a Chimera?*, TECH MUSEUM (Apr. 23, 2009), <http://genetics.thetech.org/ask/ask308>.

57. *Id.*

58. See, e.g., Vincent Castella et al., *One Person with Two DNA Profiles: A(nother) Case of Mosaicism or Chimerism*, 123 INT'L J. LEGAL MED. 427, 428–29 (2009); Cecilia Miozsoa et al., *A Case of Chimerism in a Paternity Study*, 2 FORENSIC SCI. INT'L: GENETICS SUPP. SERIES 228, 228–29 (2009); Qiong Yu et al., *Congenital Tetragametic Blood Chimerism Explains a Case of Questionable Paternity*, 56 J. FORENSIC SCI. 1346, 1348 (2011).

59. KRIMSKY & SIMONCELLI, *supra* note 1, at 303. Even if the troublesome forms of chimerism were more common, screening for chimeras by taking reference samples from, say, the cheek *and* the blood would identify the chimeras and permit the interpretation of DNA profiles to be adjusted accordingly.

60. See Arcabascio, *supra* note 1, at 454 ("It is important to first state that one should not take the 'Chicken Little' approach when dealing with this issue. The DNA sky is not falling upon the criminal justice system simply because chimerism exists.").