Color, Race, and Genomic Ancestry in Brazil

Dialogues between Anthropology and Genetics

by Ricardo Ventura Santos, Peter H. Fry, Simone Monteiro, Marcos Chor Maio, José Carlos Rodrigues, Luciana Bastos-Rodrigues, and Sérgio D. J. Pena

In the contemporary world, "race" narratives are so multifaceted that at times, different views of the concept appear mutually incompatible. In recent decades biologists, especially geneticists, have repeatedly stated that the notion of race does not apply to the human species. On the other hand, social scientists claim that race is highly significant in cultural, historical, and socioeconomic terms because it molds everyday social relations and because it is a powerful motivator for social and political movements based on race differences. In this paper we present the results of an interdisciplinary research project incorporating approaches from genetics and anthropology. Our objective is to explore the interface between information about biology/genetics and perceptions about color/race in Rio de Janeiro, Brazil. We argue that the data and interpretation of our research resonate far beyond the local level, stimulating discussion about methodological, theoretical, and political issues of wider national and international relevance. Topics addressed include the complex terminology of color/race classification in Brazil, perceptions about ancestry in the context of ideologies of Brazilian national identity, and the relationship between genetic information about the Brazilian population and a sociopolitical agenda that turns on questions of race and racism.

In the contemporary world, "race" narratives are so multifaceted that at times different views of the concept appear mutually incompatible. For example, in recent decades biologists, especially geneticists, have repeatedly stated that the

Ricardo Ventura Santos is Associate Professor at the National Museum, Federal University of Rio de Janeiro, and Senior Researcher at the National School of Public Health, Oswaldo Cruz Foundation (Escola Nacional de Saúde Pública/FIOCRUZ, Rua Leopoldo Bulhões 1480, Rio de Janeiro, RJ 21041-210, Brazil [santos@ensp.fiocruz.br]). **Peter H. Fry** is Professor at the Federal University of Rio de Janeiro (Departamento de Antropologia, Instituto de Filosofia e Ciências Sociais/UFRJ, Largo de São Francisco de Paula 1, sala 408, Rio de Janeiro, RJ 20051-070, Brazil). **Simone Monteiro** is Senior Researcher at the Oswaldo Cruz Institute, Oswaldo Cruz Foundation (Laboratório de Educação em Ambiente e Saúde/IOC/FIOCRUZ, Avenida Brasil 4365, sala 22, Rio de Janeiro, RJ 21045-900, Brazil). **Marcos Chor Maio** is Senior Researcher at the House of Oswaldo Cruz, Oswaldo Cruz Foundation (Departamento de Pesquisa/COC/FIOCRUZ, Avenida Brasil 4036, sala 403, Rio de Janeiro, RJ 21040-361, Brazil). **José Carlos Rodrigues** is Professor at the Fluminense Federal University and Associate Professor at the Catholic University (Departamento de Comunicação Social/PUC, Rua Marquês de São Vicente 225, Rio de Janeiro, RJ 22070-000, Rio de Janeiro, Brazil). **Luciana Bastos-Rodrigues** is a PhD student in the Department of Biochemistry and Immunology at the Institute

notion of race does not apply to the human species (REGWG 2005; Templeton 1999). On the other hand, social scientists claim that race is highly significant in cultural, historical, and socioeconomic terms because it molds everyday social relations and is a powerful motivator for social and political movements based on racial differences. Polysemous definitions of race are nothing new; they are exemplified by the affirmation that "race is less a biological fact than a social myth and as a myth it has in recent years taken a heavy toll in human lives and suffering," found in the declarations on race promulgated by UNESCO after World War II, especially during the 1950s and 1960s (Barkan 1992; Haraway 1989; Montagu 1997).

From the history of science, we know that both anthropological and biological thinking have played important roles in constructing a reified view of "race." This was especially

of Biological Sciences, Federal University of Minas Gerais (Instituto de Ciências Biológicas/UFMG, Avenida Antônio Carlos 6627, Belo Horizonte, MG 31270-010, Brazil). **Sérgio D. J. Pena** is Professor in the Department of Biochemistry and Immunology at the Institute of Biological Sciences, Federal University of Minas Gerais (Instituto de Ciências Biológicas/UFMG, Avenida Antônio Carlos 6627, Belo Horizonte, MG 31270-010, Brazil). This paper was submitted 3 VI 07 and accepted 29 XII 08.

true in the social and political climate permeated by colonialism that prevailed in the nineteenth and early twentieth centuries (Hannaford 1996; Stocking 1968). In recent decades, however, genetics has risen as a powerful voice against racialism. Current genomic research, to a large extent confirming the results of pioneer studies from the 1970s (Lewontin 1972), demonstrates that human biological variability is not compartmentalized in closed categories such as race (see review in REGWG 2005). As Paul Gilroy comments, "[the distance of genomic constructions of race] from the older versions of race thinking that were produced in the eighteenth and nineteenth centuries underlines that the meaning of racial difference is itself being changed as the relationship between human beings and nature is reconstructed by the impact of the DNA revolution and of the technological developments that have energized it" (Gilroy 2000, 14–15). However, as Gilroy (2000, 52) himself observes, an "antirace" position supported by genetics may compromise the position of groups whose legal and even democratic vindications rest on emphasizing racial categories.

As the "new genetics" (or genomics) increasingly influences human society in such diverse areas as health, reproductive technology, and social identity (Gibbon and Novas 2007; Goodman, Heath, and Lindee 2003; Pálsson 2008; Rabinow 1992; Strathern 1992; Wade 2002), there is growing interest in investigating how new biological information is assimilated and how it interacts with cultural categories circulating in society. In recent years, a growing number of authors have tried to investigate how knowledge of genetics relates to established notions about race, human nature, and identity (see, e.g., Brodwin 2002; Condit, Parrot, and Harris 2002; Condit et al. 2004; Wade 2002).

At present in Brazil we are experiencing many such debates about race, science, and society. During the 1990s, intensified discussion about the role of color and race in generating and maintaining social inequalities led to the formulation of a series of public policies designed to address these questions, especially in the areas of education and health (Fry 2000, 2005; Fry et al. 2007a, 2007b; Htun 2004; Santos and Maio 2004). Some authors have pointed out that in Brazilian society, this effort may lead to the spread of a reified view of race (Fry et al. 2007a, 2007b; Maio and Monteiro 2005; Maio and Santos 2005). At the same time, the results of genomic studies that emphasize the considerable extent of biological admixture in the Brazilian population have been widely reported in the media (Alves-Silva et al. 2000; Carvalho-Silva et al. 2001; Parra et al. 2003; Pena 2005; Pena and Bortolini 2004; Pena et al. 2000), bringing up further questions about the implementation of public policies based on race (Fry et al. 2007a; Santos and Maio 2004, 2005).[1] These findings conflict with the

agenda of social movements, largely influenced by the North American experience, that attempt to generate a sense of bipolar racial identity (black and nonblack or white and nonwhite) at the collective level in a country in which color/racial lines traditionally have been blurred. The "destabilizing" dimension of genetics, in the sense indicated by Gilroy (2000), is evident in the way the leadership of the black movement in Brazil has reacted to the dissemination through the media of genetic research, often criticizing it for supposedly supporting the "myth of racial democracy" (Santos and Maio 2004, 2005).

It was within this social and political context that a group of anthropologists and geneticists designed research that was intended to contribute to the lively debate on the relationship between race and genomic science as they are perceived among young people in Brazil. The research, which focused on students at a high school in metropolitan Rio de Janeiro, demonstrates to what degree the perception and understanding of human genetic variation may be influenced by the cultural and political construction of identity based on race and color. Our analysis, which evolved as we heard and discussed the students' responses at various stages and levels of the research, is pertinent to understanding the complex ways in which information about genetics may be interpreted by the lay public and why it pervades the politics of race and/or racism, affecting national policies designed to promote social inclusion. As we point out, the data and interpretation of our case study may be seen as having relevance to theoretical and practical issues of wider national and international importance.

Study Population and Methodology

Study Population

The aim of our study was to investigate how sociocultural aspects of color and race among young Brazilians interrelate with dimensions of biology and genetics. Looking for a place to carry out the research, we contacted several high schools in metropolitan Rio de Janeiro and decided on a technical high school specializing in chemistry. The criteria for our choice included the interest in participating in the research shown by the directors, professors, and students of the school; its geographic location and conditions of access (distance from the center of Rio de Janeiro); and the size of the school (number of students enrolled).

The school, Centro Federal de Educação Tecnológica de Química de Nilópolis (known as CEFET/Chemistry; http://www.cefeteq.br), is a federal government high school that in

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1. The critics argue that the major cause of social inequity in Brazil is not color or race but differences in education and income (see Fry et al. 2007a). Specific situations have polarized the debates in Brazil. For instance, in the implementation of the racial quota system, while several

universities adopted the criterion of self-declaration of color or race, from 2004 the Universidade de Brasília established a commission to "confirm" the self-ascribed color/race identity of the candidate by means of analyzing his/her photograph (Maio and Santos 2005; Steil 2006). There is also an ongoing debate about the racialization of the AIDS epidemics in Brazil (Fry et al. 2007b).

Table 1. Schematic description of the phases of the research, CEFET school, Rio de Janeiro, Brazil, 2005

Phase	Sample	Procedure
I	425 students	Questionnaire to collect information about socioeconomic characteristics (place of birth, education of parents, etc.); questionnaire to collect information about self-reported color/race classification, including open question and closed question (using the predetermined five-term system of the IBGE: branca/white, parda/brown, preta/black, amarela/yellow, indígena/indigenous)
II	90 students (randomly chosen from the sample of phase I, half males and half females age 15–19 years, one-third in each of the three IBGE color/race categories—white, brown, and black indicated in the closed question in phase I) [final sample of phase II was 87 students because of three losses]	Photo taken of each subject as well as buccal smears for genomic analysis; questionnaire to collect information about perceived ancestry
III	36 students (randomly chosen from the sample of phase II, half males and half females, one-third in each of the three IBGE color/race categories—white, brown, and black indicated in the closed question in phase I)	Each of the 36 students was asked again about self-reported color/race classification; using the photographs, each of the 36 students was asked to classify their peers using the predetermined five-term system of IBGE
IV	Three groups of 9–10 students (randomly chosen from the sample of phase II)	Three 60–80-minute group interviews (research themes were explored in depth, including perceptions about color/race, terminology and diversity of classificatory systems, racism in Brazil and in the school environment, and the relationship between self-perception of ancestry and the genomic results)

Note. IBGE = Brazilian Institute of Geography and Statistics.

addition to awarding the high school diploma prepares young people to become chemical technicians. In 2005 CEFET/Chemistry had approximately 700 students. It is located in Nilópolis, a municipality in the metropolitan area of Rio de Janeiro located about 15 miles from the city center, with a population of about 160,000.

Although the public school system in Brazil has serious problems, both in physical structure and human resources, CEFET/Chemistry is installed in a modern building with well-equipped laboratories and auditoriums, infrastructure for physical education and leisure activities (gymnasium, swimming pool, etc.), and a well-prepared and motivated faculty. The school has such a high reputation that about 30 applicants compete for each vacancy during the annual entrance examination.

Steps of the Investigation

Fieldwork took place between April and November 2005 in four distinct phases. Table 1 summarizes the components of the four phases of the investigation.

Phase I. One week after we presented the objectives of the research to the students through a brief explanatory text (which had the further objective of laying out the terms of consent—see below), we collected socioeconomic data and color/race classifications from the students attending morning and afternoon classes (evening classes were not included). The

first questionnaire distributed consisted of questions about the birthplace and residence of the student, the birthplace and education of his or her parents, and an open question allowing the student to classify him/herself by color/race using whatever term he or she chose. On the same day, after the first questionnaire was collected, a second, shorter one was distributed, the main objective of which was also to collect data on self-classification by color/race, but this time as a closed question allowing only the predetermined five terms used by the Brazilian Institute of Geography and Statistics (or Brazilian Census Bureau; Instituto Brasileiro de Geografia e Estatística [IBGE]): branca/white, preta/black, parda/brown, amarela/yellow, and indígena/indigenous.[2]

Phase II. From the students that filled out the questionnaires in phase I, a random sample of 90 students was drawn, 30 of whom had classified themselves as white, 30 as brown, and 30 as black (according to the classification in the closed ques-

2. One reviewer of this paper made the comment that we used an "outdated "system of race/color classification. We should point out that the main reason that we decided to use the IBGE system is that this system has been widely used in epidemiological, demographical sociological studies, and, more important in the context of this article, in population genetics studies with which we wished to make comparisons. In collecting information on the student's color/race, we asked the same question as the IBGE uses in collecting nationals census data ("What is your color/race"). See Nobles (2002) and Osorio (2004) for analyses of the color/race categories of the Brazilian censuses.

tion of phase I). Males and females were equally represented in each color/race group.[3] In this sample, only students between the ages of 15 and 19 years were included, the age group of approximately 90% of those who filled out the questionnaires in phase 1. The students were not informed about the criteria for the color/race composition of the sample. Each member of the sample was given an identification code number and was photographed (against the same background and under the same lighting conditions). A biological sample was taken from each student by buccal smear for genomic analysis (see below). These students filled out a third questionnaire, the purpose of which was to bring out the perception of each student concerning his or her biological ancestry. They were asked how they would estimate, by percentage, their biological ancestry with reference to the three components widely regarded as the "founders" of the Brazilian population: European, African, and/or Amerindian (e.g., a possible answer might be 30% European ancestry, 40% African, and 30% Amerindian).

Phase III. From the 90 students included in phase II, a subsample of 36 students was randomly drawn (one-third from each color/race group according to the self-classification of the phase I closed question, with half males and half females). Two different activities were undertaken. First, the 36 students were asked again to classify themselves (without seeing the color/race self-classification answers given in phase I). The aim of this procedure was to compare self-classification on two different occasions. Second, using the photographs taken in phase II, each of the 36 students was also asked to classify his or her colleagues of the phase II sample according to the five IBGE categories (heteroclassification or classification by others). To place a photograph in a given color/race category, we adopted a criterion requiring at least 50% agreement among the classifiers (i.e., at least 18 placements in the same color/race category). If the subject was not classified as either white, black, brown, yellow, or indigenous by at least 18 of the evaluators, it was classified as "other."

Phase IV. Group structured discussions were held with the phase II students. In these discussions, various questions relating to the research were explored in depth, including perceptions of color/race, terminology and diversity of classificatory systems, racism in Brazil and in the school environment, and the possible effect of the results of the research on public policy relating to color/race (e.g., a system of quotas for access to higher education). Each participant was given the results of his or her genomic profiling in a sealed envelope, with the explicit instruction that he/she had the option to disclose it or not to the group as a whole. During the group sessions, the relationship between the self-perception of ancestry and the genetic results was discussed.

Genomic and Statistical Analyses

Analysis of the genomic profiles was carried out in the Biochemical Genetics Laboratory of the Department of Biochemistry and Immunology of the Universidade Federal de Minas Gerais. DNA samples extracted from buccal smears of the students were independently typed for 40 biallelic short insertion/deletion polymorphisms (INDELS) selected among those described by Weber et al. (2002). The polymerase chain reaction (PCR) amplifications used four multiplex reaction systems, each one consisting of a mix of 10–12 primer pairs. All technical aspects have been described in detail in Bastos-Rodrigues, Pimenta, and Pena (2006). As demonstrated by these authors, these 40 INDELS are sufficient for a characterization of human population structure at the global level and can be used with especially high reliability to discriminate European, African, and Amerindian ancestries.[4]

The proportion of European, African, and Amerindian ancestry of each student was estimated using the Structure program, version 2.1 (Pritchard, Stephens, and Donnelly 2000). The Structure software uses multilocal genotypes to infer the structure of each population and to allocate individuals to different populations. The individuals are grouped (probabilistically) on the basis of their genotypes, while the allelic frequency of the population is estimated simultaneously. We used 50,000 burns in steps followed by 250,000 Markov Chain Monte Carlo iterations. As parental populations, we used individuals of European, African, and Amerindian origin available in the HGPD-CEPH Human Genome Diversity Cell Line Panel (http://www.cephb.fr/HGDP-CEPH-Panel/; Cann et al. 2002). For each run, we assumed three parental populations, used the "admixture" model, and assumed that the allele frequencies were correlated.

Based on the proportion of genomic ancestry, we assigned to each subject an individual African Ancestry Index (AAI) following the methodology described in Parra et al. (2003). The AAI, which was calculated as the logarithm of the ratio of the likelihood of a given multilocus genotype occurring in the African population to the likelihood of it occurring in the European population, represents a personal geographical ancestry estimate (Parra et al. 2003; Shriver et al. 1997). The higher the value of the AAI, the greater the proportion of African genomic ancestry of the person; conversely, the lower

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3. During the following steps of the research, three individuals were lost from the group that was self-classified as black. For this reason the phase II sample had 87 participants (30 self-classified as white, 30 brown, and 27 black).

4. The INDELS investigated in this paper are DNA polymorphisms that indicate ancestry and should not be interpreted as "racial markers." They constitute a small but random sample of the total human genome. Studies performed with the HGDP-CEPH Diversity Panel (1,064 individuals from 52 populations) showed that these 40 loci were sufficient for a characterization of human population structure at the global level (Bastos-Rodrigues, Pimenta, and Pena 2006). The loci appear to be selectively neutral, their geographical pattern of variation having emerged by genetic drift.

Table 2. Frequencies of categories indicated in the responses to the open-ended question about self-reported color/race classification, according to sex, CEFET school, Rio de Janeiro, Brazil, 2005

Categories	Males		Females		Total	
	n	%	*n*	%	*n*	%
Alva (light skinned)	1	.5	. . .	. . .	1	.2
Amarela (yellow)	1	.5	1	.4	2	.5
Branca (white)	76	38.4	104	45.8	180	42.4
Cabocla (mixed)[a]	1	.5	. . .	. . .	1	.2
Caucasiana (Caucasian)	1	.5	. . .	. . .	1	.2
Humana (human)	2	1.0	. . .	. . .	2	.5
Indígena (indigenous)	1	.5	1	.4	2	.5
Mameluca (mestizo)[b]	1	.5	. . .	. . .	1	.2
Marrom (brown)	2	1.0	. . .	. . .	2	.5
Mestiça (mestizo)	2	1.0	2	.9	4	.9
Misturada (mixed)	. . .	. . .	1	.4	1	.2
Morena (mulatto)	17	8.6	13	5.7	30	7.1
Morena clara (light mulatto)	6	3.0	1	.4	7	1.6
Morena escura (dark mulatto)	1	.5	. . .	. . .	1	.2
Mulata (mulatto)	. . .	. . .	1	.4	1	.2
Negra (black)[c]	26	13.1	24	10.6	50	11.8
Parda (brown)	60	30.3	77	33.9	137	32.2
Preta (black)	. . .	. . .	1	.4	1	.2
Not declared	. . .	. . .	1	.4	1	.2
Total	198	100.0	227	100.0	425	100.0

[a] *Cabocla* refers to peasants of mixed Portuguese and indigenous ancestry.
[b] *Mameluco* is a term of Portuguese origin describing the first-generation offspring of a European and an Amerindian.
[c] *Negro* refers to black in the sense of the black activists in Brazil.

the value, the greater the proportion of European genomic ancestry.[5] For visual display of the ancestry proportions of each individual, we used the graphic software Triangle.plot acquired in the R Graph Gallery, which is available at http://www.r-project.org.

Ethical Aspects

The research protocol was approved by the Committee on Ethics of the National School of Public Health of the Oswaldo Cruz Foundation and by the Committee on Ethics of the National Health Council, which is affiliated with the Brazilian Ministry of Health. Free and informed consent was given by all participants. In the case of students under the age of 18, the terms of consent were signed by parents or guardians as well as by the students.

5. The African Ancestry Index (AAI) simplifies analyses by taking into account only African and European ancestries, which are the most prevalent in the population under study (i.e., it does not consider Amerindian ancestry, which accounts for less than 10% of the genomic ancestry of the CEFET students).

Results

Sociodemographic Characteristics and Color/Race Classification

A total of 425 students between the ages of 13 and 21 years, 198 males and 227 females, filled out the questionnaire in phase I. A large majority (96.7%) were born in the state of Rio de Janeiro and were between the ages of 15 and 19 (89.6%) at the time of the study. In terms of education, 40.7% of the fathers and 38.6% of the mothers had completed secondary education (11 years of study); 24.3% of fathers and 28.7% of mothers had a university degree. These are high levels of education for Brazil.

In answer to the open question on color/race, the students named 18 different terms (table 2). Only 0.2% of the students (one person) did not indicate his/her color or race. The terms with the highest frequencies were white (42.4%), brown (32.2%), black (11.8%), and moreno (brown, including the variants morena/mulatto [7.1%], morena clara/light mulatto [1.6%], and morena escura/dark mulatto [0.2%]). More girls classified themselves as white and fewer as brown or black.

In the self-classification using the IBGE five-category system (closed question; table 3), the most frequent categories were white (42.8%) and brown (39.5%). There was no statistically significant difference between the sexes ($\chi^2 = 6.66$, df = 5, $P = 0.25$).

The procedures of phases I and III allow us to compare color/race self-classification by the group of 36 students (20 males and 16 females, self-classified as 10 white, 14 brown, and 12 black) on two different occasions (4 months apart). Of the 36 students, 29 (80.6%) placed themselves in the same category on both occasions. Of the 10 who classified themselves in phase I as white, nine (90%) classified themselves as white, and one (10%) as brown. Of the 12 who classified themselves as brown in phase I, three (25.0%) classified themselves as white and nine (75.0%) as brown. Finally, of the 14 who classified themselves as black, one (7.1%) classified him/herself as white, two (14.3%) as brown, and 11 (78.6%) as

Table 3. Frequencies of responses to the question about self-reported color/race classification using the predetermined five-term system of the Brazilian Institute of Geography and Statistics (IBGE) according to sex, CEFET school, Rio de Janeiro, Brazil, 2005

Categories	Males (%)	Females (%)	Total (%)
Branca/white	81 (40.9)	101 (44.5)	182 (42.8)
Parda/brown	81 (40.9)	87 (38.3)	168 (39.5)
Preta/black	27 (13.6)	22 (9.7)	49 (11.5)
Amarela/yellow	4 (2.0)	10 (4.4)	14 (3.3)
Indígena/indigenous	5 (2.5)	4 (1.8)	9 (2.1)
Not declared	. . .	3 (1.3)	3 (.7)
	198 (100)	227 (100)	425 (100)

Note. $\chi^2 = 16.66$, df = 5, $P = 0.25$.

black. Therefore, one out of five students changed their color/race classification, and there was a general tendency toward whitening.

Comparing the classifications by 36 evaluators of the photographs in phase III with the self-classifications in phase I brought out some important differences (table 4). To place a photograph in a given color/race category, we adopted a criterion requiring at least 50% of agreement among the classifiers (i.e., at least 18 placements in the same color/race category). No student was classified as yellow or indigenous. Fourteen (16.1%) were classified as "other"; that is, fewer than 50% of the evaluators agreed on any one category. Classification by the evaluators resulted in a slight increase in whites (self-classification 34.5%, classification by others 39.1%) and a reduction in blacks (self-classification 31.0%, classification by others 23.0%) and browns (self-classification 34.5%, classification by others 21.8%).

If we analyze how each of the categories changed (table 4) we find that of the students self-classified as white, brown, or black, approximately one-sixth (14%–16%) were classified as "other" from photographs. While classification by "self" and by "other" largely agreed on the white category (83.3%), the other categories differed considerably. A quarter of the self-categorized blacks and almost half of the self-categorized browns were placed in different categories. Out of a total of 87 individuals, 26 (29.9%) were placed by the evaluators in a category that was different from the one they ascribed to themselves.

Perceived Ancestry and Genomic Ancestry

The answers of the students about how they perceived their ancestry strongly emphasized admixture. None of the students claimed to have 100% European, African, or Amerindian ancestry. The closest was a student who declared himself to be black and said that his ancestry was 99% African and 1% European. Another student declared that her ancestry was 100% African and 10% Amerindian (the only case in which the percentages did not add to 100%). When questioned, she reclassified her ancestry as 90% African and 10% Amerindian.

Students who declared themselves white (taking as a reference the closed answer in phase I) perceived their ancestry as predominantly European (mean of 61.8%), followed by Amerindian (21.1%) and African (17.1%; table 5). The perceived ancestry of blacks is notably similar but with the percentages reversed: predominantly African (63.1%) followed by Amerindian (19.8%) and European (17.0%). In the case of browns, perceived ancestry is more evenly distributed, in the descending order European (37.9%), African (33.5%) and Amerindian (28.6%).

Generally speaking, the average percentages of perceived ancestry for color/race categories as classified by others (heteroclassification using the photographs) are similar to the above, especially for those self-classified as white or black (table 5). The browns have a substantial reduction in perceived European ancestry and an increase in African and Amerindian ancestry. The category "other," made up of individuals who did not fall into any of the other categories, is markedly mixed.

The results of the genomic ancestry tests are quite different from the perceived ancestry estimates. The students who classified themselves as white are predominantly European from the genomic point of view (mean of 88.7%); in second place is African (7.2%); and in third place is Amerindian (4.1%; table 5). For browns, the profile is similar: European ancestry predominates (80.3%), followed by African (11.7%) and Amerindian (8.0%). In the case of those who classified themselves as black, it is striking that European ancestry still predominates (51.7%), followed by African ancestry (40.9%), with Amerindian ancestry only amounting to 7.4%. In effect, all students estimated their Amerindian ancestry well above levels revealed by the genomic tests.

When we use classification by others as the criterion, we find that whites become, on the average, slightly more European from a genomic point of view (90.3% compared with 88.7% when self-classified) and the blacks more African (51.3% compared with 40.9%). Those classified by others as brown are also less European than when self-classified (74.6% compared with 80.3%). Generally speaking, the profile is not

Table 4. Comparison of color/race categories derived from self-reported classification and classification by evaluators (heteroclassification) using photographs, sexes combined, CEFET school, Rio de Janeiro, Brazil, 2005

Heteroclassification	Self-classification			Percent heteroclassification
	Branca/white	Parda/brown	Preta/black	
Branca/white	25 (83.3%)	9 (30.0%)	. . .	34 (39.1%)
Parda/brown	. . .	16 (53.3%)	3 (11.1%)	19 (21.8%)
Preta/black	. . .	. . .	20 (74.1%)	20 (23.0%)
Other	5 (16.7%)	5 (16.7%)	4 (14.8%)	14 (16.1%)
Percent self-classification	30 (34.5%)	30 (34.5%)	27 (31.0%)	87 (100%)

Note. $\chi^2 = 1.66$, df $= 2$, $P = 0.49$.

Table 5. Means and standard errors of means (SEM) of perceived and genomic ancestry according to self-reported classification of color/race and classification by evaluators using photographs (heteroclassification), sexes combined, CEFET school, Rio de Janeiro, Brazil, 2005

Ancestry	Branca/white		Parda/brown		Preta/black		Other[a]	
	Mean (SEM)	*n*	Mean (SEM)	*n*	Mean (SEM)	*n*	Mean (SEM)	*n*
Perceived:								
Self-classification:								
European	61.8 (3.88)	30	37.9 (3.44)	30	17.0 (2.62)	27	. . .	
African	17.1 (2.65)	30	33.5 (3.33)	30	63.1 (3.72)	27	. . .	
Amerindian	21.1 (2.95)	30	28.6 (3.21)	30	19.8 (2.83)	27	. . .	
Heteroclassification:								
European	61.9 (3.37)	34	24.1 (3.45)	19	18.0 (3.15)	20	37.9 (5.47)	14
African	18.3 (2.62)	34	38.7 (3.16)	19	66.5 (4.53)	20	38.2 (24.6)	14
Amerindian	19.8 (2.71)	34	37.2 (3.75)	19	15.5 (2.99)	20	23.9 (3.06)	14
Genomic:								
Self-classification:								
European	88.7 (2.63)	30	80.3 (4.65)	30	51.7 (7.07)	27	. . .	
African	7.2 (2.17)	30	11.7 (3.48)	30	40.9 (6.98)	27	. . .	
Amerindian	4.1 (0.80)	30	8.0 (2.16)	30	7.4 (2.01)	27	. . .	
Heteroclassification:								
European	90.3 (1.58)	34	74.6 (7.12)	19	41.8 (8.19)	20	81.5 (5.10)	14
African	5.6 (1.18)	34	14.7 (5.19)	19	51.3 (8.20)	20	12.4 (4.25)	14
Amerindian	4.0 (0.73)	34	10.7 (3.55)	19	6.9 (2.01)	20	6.1 (2.02)	14

[a]"Other" refers to those individuals who were not classified as white, brown, or black by the evaluators using the photographs (see "Results").

very different from that derived from self-classification for whites and browns, but for blacks there is some difference.

A graphic representation (fig. 1) of perceived and genomic ancestry helps us to understand the distributions. Each side of the triangle represents an ancestry (*Eu* = European, *Af* = African, *Am* = Amerindian). A point placed exactly in the center of the triangle would represent an individual with one-third European, one-third African, and one-third Amerindian ancestry. A point near the lower-left corner represents an individual with a high percentage of European ancestry and low African and Amerindian ancestry, while a point on the lower right indicates high African ancestry and low European and Amerindian ancestry.

We can see that in the triangle representing the perceived ancestry of whites (fig. 1*a*), the points are dispersed but with a tendency to fall toward the lower-left corner (high European ancestry). Most of the brown points are near the center of the triangle (fig. 1*b*). The black points are also dispersed but tend to fall toward the lower-right corner (fig. 1*c*).

The triangles representing genomic ancestries show very different distributions. While whites are highly concentrated on the lower-left corner (fig. 1*d*), indicating predominantly European ancestry, the black points are dispersed along the base of the triangle, indicating that while some have high African ancestry, others have high European ancestry, while others are intermediate (fig. 1*f*). Most of the browns overlap with the whites, but some are dispersed (fig. 1*e*).

Concerning the AAI, we can see that there is a great deal of overlap in the distribution of AAI values when we compare self-categorized whites, browns, and blacks (fig. 2). All the

students who defined themselves as white or brown have negative AAI values, which is to be expected because their ancestries are predominantly European from a genomic point of view. Moreover, 76.7% of whites (23/30) and 66.7% of browns (20/30) have AAI values between 0 and −20. Even the majority of self-declared black students (63.0%, or 17/27) have negative AAI values, with 55.6% between 0 and −20. In other words, the AAI profiles of self-declared whites and browns are very close, while a considerable number of self-declared blacks are indistinguishable genomically from the other two groups.

Group Interviews

The three sessions of group interviews involved 29 students, approximately half males and half females, and a third of each of the three color/race groups (self-classified white, brown, and black in the closed question). Each interview lasted 60–80 minutes.

Diverse themes were addressed in the 4 hours of interviews. Topics included, among others, forms of race prejudice and discrimination encountered in different spheres of daily life (work, leisure, love life, etc.), admixture, how people are classified by color or race, the effects of the race question on the school ambiance, and recent public policy measures related to race in Brazil (especially the racial quotas for access to higher education). It was clear that the students were familiar with the current debates in Brazil about social inequalities, especially those related to color and race. Because of limitations of space, which make it impossible to analyze in depth

the many themes addressed during almost 4 hours of discussion, we have decided to concentrate on the set most directly related to this investigation.

The students tended to reject certain terms of color/race classification, such as *preto* (black): "They say that 'preto' is the color of a pencil, but race is 'Negro'"; "Preto is a color; Negro is a race." Not only terms of race classification, but classification itself tended to be seen as extremely complex. At various times, the students cited the high level of race mixture in Brazil and the resulting difficulty of classifying people by color or race: "Everything is so mixed, it's crazy; if you look at the whole picture, it's all tangled up."

Throughout the interviews, the researchers tried to obtain the students' views of the genomic test results, especially in relation to the students' understanding of their ancestry. As we described before, the genomic tests indicated a high proportion of European ancestry and low Amerindian ancestry in brown and black as well as in white students. When confronted with the results of their tests, some students showed no surprise because their test was as they expected (in other words their perception of their ancestry was close to the genomic ancestry revealed by the tests). Others reacted with rejection and even dismay. Two kinds of reactions stand out.

First, students who had classified themselves as white generally declared themselves "disappointed" with the low percentages of African and Amerindian ancestry in their genomic reports, because they saw themselves as more "mixed" or as having a more "even or balanced" ancestral makeup. ("What I wrote down was more balanced"; "I don't know—I thought that the African and the Amerindian would be almost in balance"; "I classified myself before more by my looks, by my features, and I'm completely different"; "I think it could be a little bit more balanced"). Second, other students were disconcerted when their genomic tests showed high levels of European ancestry—a result that, in principle, they would not have imagined possible. One student who classified himself as black even commented that there must be some "trick" going on: "I'm absolutely certain that it is wrong (the genomic test result). . . . You [the researchers] made everybody white [in other words, with more European genomic ancestry] just to find out what we were really thinking." Another stressed the uneasiness that the test caused him: "It's strange, you think it's one thing and it's something different. . . . I don't know, it's sort of weird, sort of unsettling."

Many students whose expectations about their ancestry were not confirmed by the test results pointed out that they
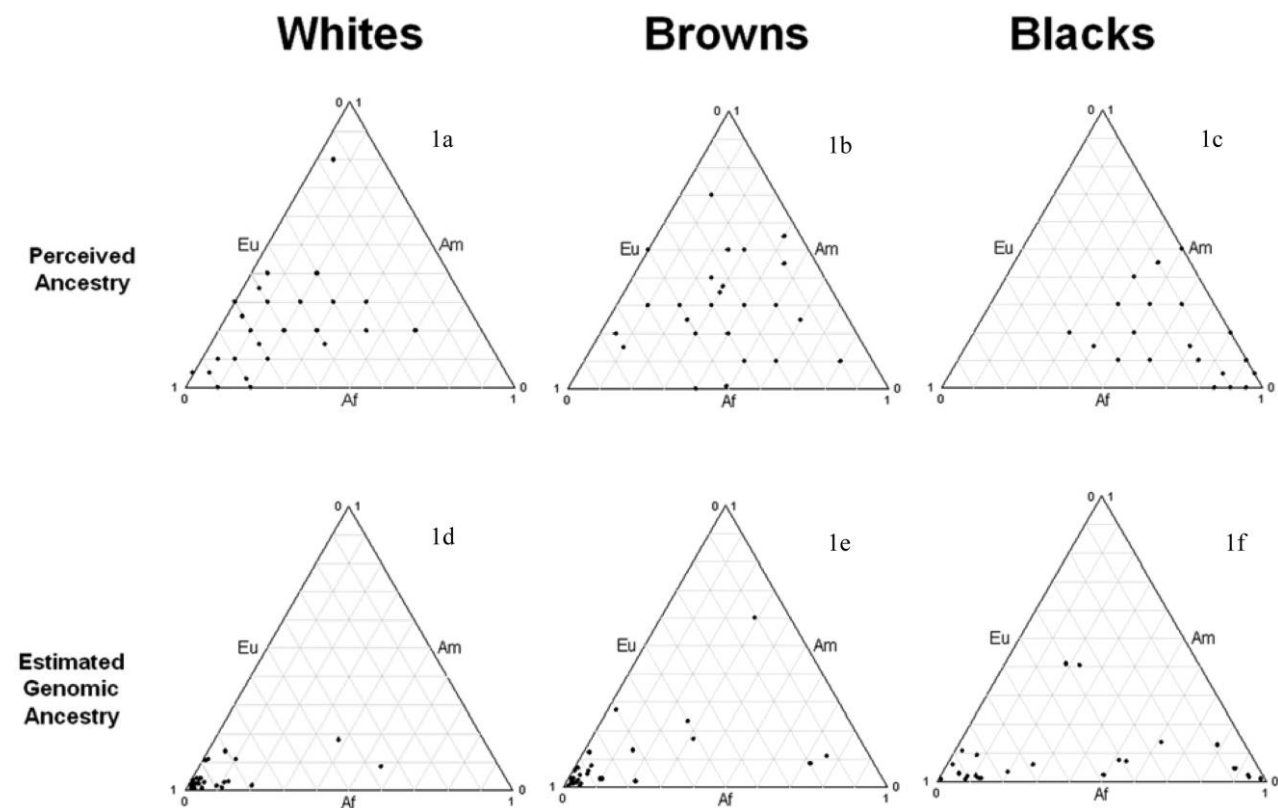

Figure 1. Comparison of perceived and genomic ancestries (*Af* = African, *Am* = Amerindian, *Eu* = European) according to self-reported classification of color/race, sexes combined, CEFET school, Rio de Janeiro, Brazil, 2005.

Figure 2. Distribution of the African Ancestry Index (AAI) according to self-reported classification of color/race, sexes combined, CEFET school, Rio de Janeiro, Brazil, 2005.

did not know their family history in depth, which might explain the results: "My father is black, my mother is brown, almost white. . . . My grandmother was white too; my grandfather was brown. . . . I just don't know where that 97% (of European ancestry) came from. I'll ask about it at home"; "I can't say much because I didn't know them, the people on my grandfather's side, because they came from the Northeast"; "Because this research is based on a person's genealogical tree going way back, and the most we can know are our grandparents and great-grandparents."

Another point the students emphasized was that they had generally based the estimates of their ancestry on their phenotypic characteristics, which might not be in accord with genetic criteria. "It's that we classify ourselves by how we look. We only take our color into account. I classified myself as brown. When I classified myself I wrote that I had a high African percentage. When I saw it (the result of the genomic test) the percentage was small relative to the European, because I classified myself by my features, by my physical appearance." Another student commented: "Not everything we see is real. . . . Appearances deceive. A lot. In this case they deceived a lot. Really a lot." Another one commented: "We are the result of so much admixture that by now the races can't be separated."

Although the students frequently talked about the similarities and the differences between their own perceptions of their ancestry and the results of the genomic tests, throughout the three discussion sessions there was almost unanimous agreement that the genetics tests would not change people's lives very much. Many comments were along the lines of "no difference to me. . . . It won't change anything in my life to know that 95% of me is European"; "I think it won't matter in my life. . . . It is just another piece of information about me. I'll hang on to it"; "Nothing will change in my life"; "Well, it has changed, but only on paper"; "It was fine to do like we did . . . to get to know about our percentages. But it won't matter at all in our lives. . . . People aren't going to

accept me any more because I'm 90% European. If I were 90% African they would accept me just the same way"; "I consider myself black, and it's not because I'm 98% European that I'll start thinking of myself as not being black"; "Only at the level of curiosity . . . it was nice to know what my ancestors were . . . but I think that changing that doesn't change really anything"; "I don't think there is any way we can assimilate this DNA test into our real lives."

Some students, however, brought up examples of ways that the test results might have some effect on their personal lives by reaffirming or overturning imagined notions about their ancestry. One girl, who had classified herself as brown, talked about her ambition to become a ballet dancer; but, according to her, the admission process of ballet companies, especially classical ballet, favored girls with whiter skin. She said jokingly that at the next admission exam she was going to dance with the genomic test results glued to her forehead, proving her predominately European ancestry. Even so, "I think that even if they see it [the test] they will continue only to really see my appearance, my color, and judge me by what they see, you understand? . . . They will continue to see me as brown, dark-skinned." A black student, whose test confirmed his expectations of ancestry, declared, "It has changed me, because now I know I'm black. I have nothing European."

The students tended to minimize the effect of the genomic tests on the practice of racism in Brazil as well as on the struggle against racism. "It's because racism is based on that thing you see, skin color. It's already defined." In the vision of some participants, at present, society is not yet prepared for a transformation of mentality through genomic evidence. But it could happen in the future. "These results won't change anything today. But who knows, in time it might change people's concepts." There were, however, students who pointed out the possibility of producing a broader transformation of mentalities.

As was to be expected, given that the participants are young people who hope soon to be applying to the university, racial quotas for admission to higher education is a subject that grips them. Talking with the students made it clear that in the school, the subject is heavily, even tensely, debated. According to one of them, "in the discussion about quotas people who were in the midst of the debate even cried." The students in the discussion group tended to be against the quotas, but at times they mentioned that some in the school favored them. No student openly defended the quotas. Some said that, on the contrary, the quotas would be "a kind of discrimination"; "sort of a way of practicing hidden or disguised racism"; "Essentially it is . . . division by race. . . . Everybody has some of every race . . . so this policy of quotas by race can't exist;" "it's disparaging to blacks, making it look as if blacks are stupid." They emphasized that the way to go should be through improvement in public education (remember that CEFET is a federal public school), preparatory preadmission courses and more openings in the universities or else by establishing "social quotas" (places reserved for

students graduating from public schools, regardless of color or race, with the supposition that most poor people in Brazil are black). There still would be an entrance problem for those chosen by quota, as well as the difficulty of staying in school. In the view of many, the quotas are insulting to blacks: "[the quotas suggest] that blacks are less intelligent"; "people that enter through the quota, I think they are inferior to others. . . . It shows up their inferiority."

The students made a number of associations between the results of the ancestry test and access to the quotas. "I have the best chance of getting on the quota . . . 11% Amerindian— wow! Great!"; "Mine is 96% European, 1% Amerindian, 3% African. I guess the only thing that changes is that I don't have a chance of getting on the quota." But he added, "I'm kidding." The dominant view was that the genetic results, whatever they were, would not have much influence. "It is important to know about them, but, beyond this, this knowledge is not worth anything at all"; "this business of tests is a nice curiosity, and so what? . . . I'll bet that when I apply they won't take the test results into account. . . . In spite of that high percentage of European ancestry I won't cease to be 'black'; never!"

Discussion

Our study has produced a large data set of an anthropological and genetic nature, the connections between which allow us to address a wide set of issues. We have chosen to structure the discussion around three basic topics that range from specifically methodological issues to the implications of our findings for the wider social and political environment. First, we discuss the relevance of our findings for future research into human biological variation in Brazil, including its methodological aspects. Second, we expand on how our results shed light on the complex interaction between recent biological knowledge and more traditional understandings of ancestry and descent in Brazil. Third, we discuss some of the social and political implications of the dissemination of information on the genomic profile of Brazilians.

Genomics is exercising an increasing effect on people's daily lives, affecting such diverse areas as health, reproductive technology, and social identity. Because of this, anthropologists and other social scientists have a growing interest in investigating how new biological information is assimilated and how it interacts with cultural categories circulating in society (Brodwin 2002; Condit, Parrot, and Harris 2002; Condit et al. 2004; Gibbon and Novas 2007; Goodman, Heath, and Lindee 2003; Pálsson 2008; Rabinow 1992; Shriver and Kittles 2004; Strathern 1992; Wade 2002; Winston and Kittles 2005). As pointed out by Lindee, Goodman, and Heath (2003, 1), "genomes, human and other, are dynamic, emergent entities still under negotiation as territory, property, soul, medical resource, and national prize. . . . Meanwhile, narratives of both technoscientific expertise and everyday life have come

to be scripted in a genetic idiom deployed by laypeople and the experts alike."

Among recent studies, that by Condit, Parrot, and Harris (2002) has special interest for our case study. In order to investigate what the authors call "lay understanding" of the relationship between race and genetics, they assembled 17 focus groups: four of white males, four of white female, five of black females, and four of black males. The members of the groups had not been previously acquainted with each other, and all were living in a city of the southeastern United States. As they analyzed group discussions, Condit, Parrot, and Harris (2002) found that most of the groups produced a social knowledge of genetics and race "as a complicated territory of shared and distinct characteristics" (pp. 379–380). They also observed that the discussions in the focus groups involved a process of "mutual correction or augmentation" (p. 380) in a way that "[the] sum of collective social knowledge is greater than their individual knowledge" (p. 381). These two aspects, related to the complex discursive interaction between race and genetics and the collective dimension of social knowledge production, were also key aspects in our CEFET study.

But Condit, Parrot, and Harris's paper brings out other important aspects of this kind of research, especially the social and cultural environment that encompasses both researchers and the "researched." In Condit, Parrot, and Harris's study (2002), apparently the researchers had no difficulty in recruiting blacks and whites and putting them in separate groups. These "identities" appear to occupy the status of categories taken for granted by all concerned. The CEFET study, on the other hand, reflects the distinct way in which researchers understand the meaning of race in Brazil. We took no racial category for granted, building our research on the way the students classified themselves and others. Furthermore, in setting our questions, we were very careful not to impose an a priori racialized view of the world, asking the students to define their ancestry not by race but by origin from distinct *geographical* locations: Africa, Europe, and the Americas themselves. An exception was our utilization of the census categories, which was necessary to enable comparison with other data. In no way should it be understood to suggest that such categories represent anything other than a particular way successive Brazilian governments have chosen to classify by race and color (see Nobles 2000, 2002).

An important element of the CEFET case study is the effect of the disclosure of the results of the genetic tests on the students. We should not forget that these students are members of a community with shared interests, deeply concerned with the implementation of the national policy of racial quotas governing access to higher education, which they freely discussed as directly affecting their lives, because they all share an ambition to enter the university. The individual perspectives of the students were modulated by the wider collective and sociopolitical context, resulting in complex negotiation between their ancestry as they perceived it and their genomic

ancestry presented to them as scientific results. The students did not accept passively the information that genomic science revealed about their ancestry. At times, when the genomic ancestry report was not in alignment with their self-characterization of ancestry, they reacted by relegating "scientific fact" to a secondary level of importance, both in their own lives and in the wider sociopolitical sphere.[6] These are important issues to which we will return when we further address the genomic results.

The proposal for this research—involving anthropologists, sociologists, and geneticists, and using a combination of quantitative and qualitative methods to obtain data on color/race and ancestry—emerged from a critical view of the way that genomic research is being conducted in Brazil and in Latin America. In recent years, a growing number of genomic studies have been carried out in various regions of Brazil, a significant portion of them seeking to analyze differences in the European, African, and Amerindian genetic contributions to the Brazilian population (Alves-Silva et al. 2000; Carvalho-Silva et al. 2001; Gonçalves et al. 2007; Hünemeier et al. 2007; Marrero et al. 2005; Pena and Bortolini 2004; Zembrzuski, Callegari-Jacques, Hutz 2006).[7] The aim of our research is to go beyond these studies—which generally have been based on the classification of the color/race of individuals, either by the subject or by others, according to a specific set of categories, primarily that used by the IBGE—by adopting multiple approaches to classification. Moreover, we gave priority to investigating the subjects' own perceptions of their ancestry and how these perceptions complemented or conflicted with their ancestry as indicated by genomic techniques. Our findings on the complexity of racial classification should not therefore be looked at in isolation as just another effort to describe the Brazilian race-classification system, which has already been thoroughly discussed in the literature (Fry 2000, 2005; Harris 1970; Nogueira 1998; Silva 1994; Telles 2004; Wagley 1965), but rather as representing the maximum amount of care in classifying members of the sample. In methodological terms, this study stresses the importance of broadening the scope of research on genomic ancestry by combining biological information with due attention to anthropological and subjective approaches.

The 18 different terms that the members of the study sample used when asked to freely choose a term to describe their own color or race (table 2) indicate that the students have internalized a diversified classification system. Although the primary objective of our study was not to investigate color/race classification systems per se, these findings are relevant insofar as they show that, despite its small size and geographical location, the sample of CEFET students employ a rich

and diverse racial terminology as has been described for the Brazilian population in much larger studies. This terminological multiplicity is famous. In the 1970s, the IBGE carried out research on the national level, finding 135 different terms to classify color or race, with important differences among the regions of the country (Osorio 2004; Telles 2004).

Another relevant aspect, the malleability of the color/race classification system in Brazil, is reflected not only in the terminology but also in the notable lack of consistency in applying the terms. The way a person is classified may depend on the context, as various authors have pointed out (Harris 1970; Nogueira 1998; Silva 1994; Wagley 1965). We can see this exemplified in the CEFET study when we compare self-classification in two different occasions and well as self-classification with classification by others. We observed that close to 20% of the students "changed" their color/race when we compared self-classification 4 months apart. In addition, when a group of students who had classified themselves, using closed categories, was classified again, this time by their colleagues from photographs, we observed that 20% changed category, with a tendency toward "whitening." Approximately a quarter of the brown and black individuals were reclassified into lighter groups. When "self" and "other" classifications are compared, the percentage distributions of color/race categories (white, brown, and black) are similar (table 4). However, if we analyze the categories individually, we find that the photographs of approximately half of the students who classified themselves as brown and a quarter of those who classified themselves as black were not classified by colleagues in the same group.

A very important point is that although the results of our investigation point in the same direction as numerous other case studies that have been carried out in Brazil from the standpoint of anthropology and sociology,[8] we do not claim that it should be regarded as representative beyond its local context. In other words, because the research took place in a specific school in Rio de Janeiro, we do not argue that we can draw conclusions from the context of the study that would necessarily be representative in the wider national context of

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6. Unfortunately the research design did not include investigation of the students' preexisting notions of blood, kinship, genetic inheritance, etc. We wish we had collected these data, which would have been very useful to interpret our findings.

7. See Salzano and Bortolini (2004) for a review of this research.

8. Another convergence is that the color/race distribution of CEFET students is similar to that of the region where the school is located. Census data for the year 2000 indicate that for the age group 15–19 years old of the Nilópolis county, 46% declared themselves white, 42% brown, 11% black, 0.1% yellow, 0.2% indigenous, and 0.7% did not declare their color/race (compare with results in table 3). This information was obtained from the IBGE website, http://www.ibge.gov.br, SIDRA tables, May 15, 2007. This similarity in the statistics stands out as indicating that while entrance to CEFET is highly competitive, admissions does not seem to be biased against darker-skinned applicants. The fact that browns and blacks are not underrepresented in this highly competitive environment indicates that at least in terms of access to the best that free public education has to offer in Rio de Janeiro, darker-skinned students are not at a disadvantage. Although it is unquestionable that racism and discrimination are present in Brazilian society, the hope is that the provision of free education of quality is a necessary and perhaps a sufficient condition for overcoming many of the "racial" disparities that are such a depressing feature of the Brazilian social landscape.

Brazil. However, these results provide us with a firmer ground to discuss the possible methodological implications of the use of different systems of color/race classification as they relate to the study of human biological variability, to which we now turn.

The similarities and differences in the classification profiles that result from "self" and "other" classification are relevant to debates about what research methodology is appropriate for the study of human biological variability in Brazil. Studies produced in recent years have relied mainly on self-classification (Alves-Silva et al. 2000; Carvalho-Silva et al. 2001; Suarez-Kurtz et al. 2007), but some influential studies are based on classification by others (Parra et al. 2003; Zembrzuski, Callegari-Jacques, and Hutz 2006), with later works comparing the results obtained through these different procedures. The results of our study indicate general concordance between self-classification and classification by others. However, if we look at studies with different distributions of color/race, especially those with a larger number of brown individuals, there is the possibility that more will be reclassified when "self" and "other" classifications are compared. This is exemplified in table 6, which presents a simulation that, using the CEFET data as reference, compares different percentages of self-classification according to color/race group (hypothetical data). In samples with a larger percentage of brown and black individuals, more are reallocated to a different category when classified by others. In the case of a sample with 75% self-classified as brown, 12.5% as black, and 12.5 as white, approximately 40% would be placed in a different category when classified by others. In our study, with the percentages of white, brown, and black approximately one-third each, the difference between "self" and "other" classification is not significant, while in studies largely made up of browns and blacks, there is the possibility of wide differences between the results of "self" and "other" classification.

Beyond their relevance concerning methodological issues in human biological research in Brazil, our findings allow us to think about a number of points related to the status of biological knowledge vis-à-vis sociocultural views of ancestry in Brazil. The CEFET results make it possible to address how ideologies about the history and structure of the nation are reflected at the level of the individual and reveal how much (or little) significance people attribute to scientific information, at least regarding "race" in their daily lives.

A dominant perspective of Brazilian society is that it sees itself as the product of "race admixture" brought into being through the meeting of Europeans, Africans, and Amerindians. This is the founding myth of Brazilian nationality, which carries heavy symbolic weight (DaMatta 1981; Freyre 1933; Fry 2000; Maio 2001). The way that the CEFET students answered questions about how they perceived their ancestry showed that they all viewed themselves as racially mixed. Whether from a collective or an individual viewpoint (none of the students said that they were 100% European, African, or Amerindian), the discourse of admixture is strongly em-

Table 6. Expected percentages of reallocation in the hetero-classification of color/race of different combinations of color/race self-classification

Percentages from self-classification			Percentage of reallocation based on heteroclassification[a]
Branca/white	Parda/brown	Preta/black	
34.5	34.5	31.0	29.9
50.0	25.0	25.0	26.5
25.0	50.0	25.0	34.0
25.0	25.0	50.0	29.0
75.0	12.5	12.5	21.6
12.5	75.0	12.5	40.4
12.5	12.5	75.0	27.4

[a]Percentage of reallocation using CEFET results (derived from table 4).

phasized. It is almost as though each student saw him/herself as a product of what Brazilian anthropologist Robert DaMatta (1981) termed the "Fable of the Three Races."

It is interesting to note that Amerindian ancestry holds a prominent place, amounting on the average to one-fifth of the perceived ancestry of white and black students and to one-fourth of browns, far in excess of their genomic "presence." White students saw themselves as having more Amerindian than African in their ancestral mix, while black students saw their mix as containing more Amerindian than European. The powerful presence of Indians in Brazilian culture, even though they make up less than 0.5% of the country's population, is a recurrent theme in Brazilian anthropology. Alcida Ramos (1998, 3) asks why "being so few, [Indians in Brazil] have such a prominent place in the national consciousness." She replies, "They have the power to burrow deeply into the country's imagination" because of the prominent and positive place they occupy in the construction of national identity.

The results of the tests for genomic ancestry of the CEFET students are close to those of other recent studies in Brazil (Parra et al. 2003; Pimenta et al. 2006; Suarez-Kurtz et al. 2007), all of which point to a low correspondence between color/race and genomic ancestry or, as Parra et al. write, "Brazilians form one of the most heterogeneous populations in the world, which is the result of five centuries of interethnic crosses of peoples from three continents: the European colonizers, mainly represented by the Portuguese, the African slaves, and the autochthonous Amerindians," with the result that "at an individual level, color, as measured by physical evaluation, is a poor predictor of genomic African ancestry, estimated by molecular markers" (Parra et al. 2003, 177).[9]

9. Parra et al. (2003) offer a model to explain why in Brazil color is a poor predictor of African ancestry at an individual level. They write: "[consider] the historically common Brazilian mating of a white European male with a black African slave woman: the children with more physical African features would be considered black, while those with more European features would be considered white, even though they would have

This finding may be illustrated by the results of a study by Suarez-Kurtz et al. (2007), also carried out in Rio de Janeiro, with a considerably larger sample (335 individuals) than that of the CEFET study and using the same genomic markers. The researchers observed a predominance of European ancestry (∼70% or more) in individuals who defined themselves as white and "intermediate" (equivalent to brown), and even a high percentage of European ancestry in those who defined themselves as black—on the average they had 51% African ancestry and 7% Amerindian.

Finding a high level of European genomic ancestry in the CEFET students at the same time that various studies have demonstrated the importance of the contribution (approximately 60% of mtDNA matrilineages) of African and Amerindian origins to the white Brazilian population (Alves-Silva et al. 2000) is not as contradictory as it may seem. The reason is that patterns of ancestry through matrilineal DNA reflect different processes from those through autosomal markers (those situated in the cell nucleus, as is the case of the INDELS investigated in this study). An example may help us to understand the difference. Let us suppose that an Indian woman in 1500 had a daughter (it doesn't matter whether the father was another Indian or was Portuguese), and in all the following generations, her granddaughters, great-granddaughters, great-great-granddaughters, and so on, had at least one daughter. In this case, in the year 2000 (after some 20 generations, assuming an average generation length of 25 years), all these women and their descendants would have the same mtDNA as the founding mother, unless a mutation had occurred (in other words, 100% Amerindian mtDNA in all the descendants of the Indian woman). This continuity exists because mtDNA is inherited through the mother without recombination from one generation to the next. Both daughters and sons receive mtDNA from their mothers, but only daughters pass it on; it is a uniparental marker. The inheritance of the markers used in this research (the INDELS) is different, because they are influenced by both mother and father. Sons and daughters inherit, on the average, half of their genes from each parent. In the hypothetical case of the Indian woman, if her descendants later had children with African and European men and women, over time their Amerindian ancestry would become progressively reduced. Therefore it is theoretically possible for a family whose members all have 100% Amerindian mtDNA to have low Amerindian ancestry as measured by autosomal markers such as INDELS.

This scenario is relevant to the students' view of their ancestry. When they answered the question about how they perceived their ancestry, they gave more weight to the recent generations with which they are familiar, namely, their par-

ents, grandparents, and great-grandparents, whom they referred to in the group interviews. They must also have been influenced by the image of Brazilian society as made up of the three founding stocks: European, African, and Amerindian, commonly referred to in schoolbooks and in daily life.[10] The combination of factors that affect genomic ancestry measured by INDELS has much greater temporal depth. For example, a Brazilian with ancestry going back to the time when Europeans arrived, in 1500, would have, over the approximately 20 generations up to the year 2000, two parents, four grandparents, eight great-grandparents, 16 great-great-grandparents, 32 great-great-great-grandparents, and so on, resulting in thousands of ancestors over this time period ($2 + 4 + 8 + 16 + 32 + . . . + 2^{20}$). The genetic contribution of these thousands of people, whose individual existence is lost to memory, makes up the genome of our present-day Brazilian.

A comparison of the results of the questionnaire on perceived ancestry with the genomic tests brings out some other interesting points. Referring to perceived ancestry, white and black, as well as brown students—although more of the brown, as might be expected—saw themselves as highly mixed in race. Nevertheless, white and black students perceived themselves as somewhat apart, because the ancestry of the former was perceived as predominately European, and the ancestry of the latter was perceived as predominately African. The clustering of points in the first row of figure 1—white placed to the left and black to the right, with brown in the middle—illustrates this. On the other hand, the results of the genomic tests show ancestry to be less mixed than the students perceived it to be, because both white and brown have more than 80% European genomic ancestry. The points that indicate genomic ancestry—the second row of triangles in figure 1—are mostly clustered in the lower-left corner, indicating the genomic proximity of white, black, and brown.[11] It is highly relevant that in the CEFET study, it is not the brown students but the black who are most "mixed." In the genomic sense, not only are the CEFET students less "mixed" than they perceive themselves to be, at the same time they are closer to one another genomically than they realized when they indicated their ancestry. While the browns are, in a sociocultural sense, the most mestizo, in a genomic sense, it is the blacks.

The disparity between sociocultural perceptions of race and genomic evidence has a number of different implications. In the group interviews with the CEFET students, this point came up repeatedly. But it also has dimensions that transcend this particular case study. As we mentioned before, the race

exactly the same proportion of African and European alleles. In the next generation, the light-skinned individuals would assortatively tend to marry other whites and conversely the darker individuals would marry blacks. The long-term tendency would then be for this pattern to produce a white group and a black group, which would, nonetheless, have a similar proportion of African ancestry" (Parra et al. 2003, 181)

10. This image of the Brazilian people made up of Europeans, Africans, and Amerindians is so strong in popular culture that in the 1970s, a "Cruzeiro" note was printed showing the profile of each of the three "races" (see Ramos 1998 on this point).

11. This is quite evident if we analyze the distribution of the African Ancestry Index (AAI) in figure 2, which shows how the distributions of whites, browns, and blacks overlap.

question figures prominently in Brazilian political life at present (Fry et al. 2007*a*; Htun 2004; Telles 2004). It plays an important role in the dynamics of social activism, because when the leftist Workers' Party came to power in 2002, it brought along militants from various movements, including black activists, who won positions in the new government. Among the actions of the state in the sphere of race relations are initiatives aimed at strengthening racial identity, especially "black identity." The underlying logic is that identity is an important political force, raising the hope that once Brazilians assume "black identity," undermining the image of the country as a color spectrum without distinct boundaries, there will be greater political pressure to implement public policies designed to overcome race-based inequalities. A key element of this "social engineering to strengthen race identity" is an emphasis on the black population of the country, made up of the sum of those self-categorized as brown or black in the censuses and government surveys. Combining pardos/brown (38.5% of the population according to the 2000 Brazilian national census) and pretos/black (6.2%) is often justified by the fact that socioeconomic indicators (income, education, morbidity, etc.) indicate the proximity of the two groups in contrast to the more privileged situation of whites (Hasenbalg 1985). The argument that nonwhites constitute close to half of the population of the country has been routinely used in arguing for the introduction of public policies favoring the nonwhite population, especially in the areas of education (racial quotas for entrance to the universities), the labor market, access to land, and so on. One proposal, the Statute for Racial Equality, under discussion in congress and with government support, would include a person's "racial identity," using the IBGE census categories, on all personal documents, as well as in health, education, and police records (see Fry et al. 2007*a*).

The direction that racial politics is taking in Brazil has aroused intense criticism (see Fry et al. 2007*a* for a general view of the question). Critics see the efforts on the part of the state to regulate racial affiliation, transforming the IBGE census categories into "racial identities," as highly problematic. They fear the symbolic violence of imposing racial identities on situations in daily life. They reiterate the argument that inequality in Brazil is more related to the economy and to education than to color or race. Another argument is that the notion of a nonwhite population is highly artificial. Seeing society as made up of blacks and whites, as in the United States, is regarded as foreign to the history and culture of Brazil, where the emphasis is on a society characterized by a continuum of race and color. The idea that the nonwhite population consists of those with African ancestry is also questionable, because in some regions of the country, such as Amazonia, dark-skinned people are more likely to have predominately Amerindian ancestry.

While activists stress the socioeconomic proximity of black and brown with the aim of consolidating the notion of a nonwhite population in Brazil, the results of the CEFET study

as well as others (Parra et al. 2003; Pimenta et al. 2006; Suarez-Kurtz et al. 2007) point to closer biological proximity of browns and whites. At the sociopolitical level, biological interpretations of ancestral proximity, however, may be regarded as secondary, or even irrelevant, as long as inequality between socially perceived races exists, even if it is primarily linked to socioeconomic factors, such as access to education, the labor market, and health care.

The complexity of this picture is obvious. But we would like to argue that the biological argument might carry important weight in political debates around certain themes, such as health-related issues, which are heated aspects of the race question in contemporary Brazil. Recent Brazilian government documents dealing with race and health tend to emphasize the social and economic origins of inequalities in health. However, they also suggest that the nonwhite population, defined as the sum of black and brown, has a "biological substrate." For example, the document from the Ministry of Health, "A National Policy for the Integral Health of the Black Population," states that "in Brazil there is a consensus of expert opinion concerning the health problems of the black population," among which are those "determined genetically," such as sickle-cell anemia, glucose-6-phosphate dehydrogenase deficiency, and foliculitis.[12] This emphasis on the relationship between health and race in public policy has preoccupied many (see Fry et al. 2007*a*, 2007*b*; Maio and Monteiro 2005), who criticize it as based on essentialist views of race (see Dressler, Oths, and Gravlee 2005; Goodman 2000).

Ironically, biological information derived from genomic analyses, including the CEFET results, contradicts the "natural" equivalence of brown and black that results in the sociopolitical category "black population," with important implications in the area of health. A number of other studies (Parra et al. 2003; Pimenta et al. 2006; Suarez-Kurtz et al. 2007) as well as ours have shown that people genomically characterized as brown have higher levels of European than African ancestry, which can affect their risk of suffering from such diseases as sickle-cell anemia. In our view, therefore, arguments based on genomic evidence that criticize the notion of a black population are neither socially nor politically irrelevant, considering the premises that are modeling the direction of health policy in Brazil.

The data on Brazil, which on the surface may appear specific only to that country, have implications that cross national frontiers, touching on theory and politics at the interface of race and ethnicity with the globalization of science and technology. The case of the drug Bidil is an example of these connections. The development of this drug, aimed at treating heart failure, has been at the center of recent debates about the role and significance of race/ethnicity in medical research

12. In this document, the "black population" is defined by combining census categories. "The demographic census of 2000 showed that 54% of Brazilians define themselves as white, 45% as black (black and brown), and 0.4% as indigenous and yellow."

and clinical practice. The claims of its manufacturers that the drug works better in African Americans—that is, in self-identified black patients—as opposed to other racial or ethnic groups, which gave it the first U.S. federally approved race-specific drug patent, has raised a number of issues about scientific methodology, prescription practices, commercial forces in the development of pharmaceuticals, and health inequalities (Goodman and Jones 2005; Henig 2004; Wadman 2005). The U.S. Food and Drug Administration approval of Bidil as a "racially targeted drug" has been criticized on the basis of supporting a "biologically inaccurate and socially dangerous" surrogate of race instead of emphasizing the "genetic and environmental factors that determine individual differences in drug response" (Wadman 2005, 1008).

In light of the current emphasis on race in heath policy in Brazil, we have to think about how the idea of black might come to be associated with a drug such as Bidil. The United States—where the drug was developed—has social and historical peculiarities that are well known and are different from those in Brazil. In a series of articles about the relationship between race and ancestry in Brazil, Pena (Pena 2005), Suarez-Kurtz (Suarez-Kurtz and Pena 2006) and Parra collaborators (Parra et al. 2003) have questioned the use of race as a category in medicine and pharmacology when it is based on an individual's phenotypic characteristics. A future scenario (hypothetical, but nevertheless possible—and disturbing) envisions the public health system in Brazil, if political efforts succeed, so influenced as to distribute drugs—such as Bidil—according to the politically constructed category of "black population." As recently pointed out by Suarez-Kurtz (2009, 1651) in an editorial about pharmacogenomics and the genetic diversity of the Brazilian population, "the heterogeneity and admixture of Brazilians has important implications for the design and interpretation of clinical trials [and], the implementation of pharmacogenetics/-genomics (PGx) knowledge in drug prescription. . . . The heterogeneity of our population must be dealt with as a continuous variable, which cannot be adequately represented by arbitrary 'race/color' categories."

Concluding Remarks

Gibbon and Novas (2007, 1–2), based on Rabinow's (1992) concept of biosociality, argue that "the emerging truths that are being produced about humans in the diverse field of genetics shape our identities and forms of group activism." In this study, we have explored how genomic "truths" accord or clash with the perceptions of individuals and groups about color/race in a specific setting in Brazil. For most of our CEFET students, the social, cultural, and political implications derived from exposure to these "truths" constituted complicated terrains. Our attempt has been to address their reception of the genomic information in the context of local, national, and also international historical and sociopolitical dynamics.

As we finished writing this paper, the Icelandic anthropologist Gísli Pálsson (2008) published an important article titled "Genomic anthropology: coming in from the cold?" Pálsson refers to "genomic anthropology" as "a hybrid field that increasingly involves anthropologists in the fusion of the 'social' and the 'biological' in the wake of genomic studies. . . . [It] involves the study of human genomic variation and history; it attends to basic concepts and metaphors, indigenous and otherwise, including population, lineage, race, kinship, and soul name, and engages with the implications of genomics for biopolitics and the construction of relations and identities" (Pálsson 2008, 546). Evident is the proximity of our research to the methodological, theoretical, and epistemological perspectives put forward by Pálsson. Our work, despite not "coming in from the cold" but from the balmy Brazilian tropics, also aims at "melting" disciplinary barriers in order to explore "some of the opportunities offered for anthropology in the genomic domain and . . . [to identify] both some tensions that they invite and some potential ways of resolving them" (Pálsson 2008, 558).

A central issue in current genomic research within anthropology concerns the relationships between the many parties involved: anthropologists, geneticists, and informants alike. As indicated by Heath (2008, 561), "collaboration is a relational stance that is at once ethical, political, and intellectual. . . . It is about the interplay of alterities, the mutual recognition of difference, interdependence, and interdigitated interests." About this specific point, the debates within genomic anthropology are often dominated by the polarities "experts," on one hand, and "informants" and "sample donors"—including indigenous peoples—on the other (Pálsson 2008; Reardon 2005; Santos 2002). Our study has not only paid attention to these alterities but also to those among researchers. In the final paragraphs of this paper, we would like to address some of these issues.

In a cross-disciplinary and multifaceted investigation such as this, it is difficult for the bare description of methodology and results to communicate the complex atmosphere that prevailed during fieldwork. In a way, the research setting was a "social laboratory" involving much more than data collection. In this "laboratory" we observed students engaging and resisting the themes of the research. From the very beginning of the project, when we announced that one of the procedures of the study would involve genomic ancestry tests, expressions of interest and even fascination filled their faces as they confronted the "mystique" surrounding DNA (see Nelkin and Lindee 1995). Along similar lines, Palmié (2007, 207) writes that "genomics, like divination, gives material shape to, and thereby reproduces as social reality . . . ideologies of invisible essences and agencies." In our CEFET study, often the "mystical/divinized" DNA at first had the power to attract, but the color/race categories later had the opposite effect. We observed that when the students filled out the questionnaires asking them to categorize themselves by color or race, many of them experienced obvious discomfort. They looked across at their neighbors, they ran their fingers over the skin of their

arms, and they took time figuring out how to classify themselves.

Throughout the course of fieldwork, we encouraged the research group to reflect on the possible effects the research procedures could have on themselves and the students. These procedures created situations in which students were simultaneously exposed to different "manifestations" of ancestry (based on self-perception and on genomics). It might be said that through their DNA samples, they were presented with patterns of "genetic citizenship" (Heath, Rap, and Taussig 2004) that in many instances had the potential to destabilize their previous self-perceptions. It is important to emphasize that the intent of our research was not to attribute a higher or lower truth value to scientific evidence than to other ways of perceiving ancestry but to set up a context within which individuals could express how they were negotiating these different forms of evidence based on their own life experiences and perceptions. The intertwining of these dimensions resulted in a process of "co-production" (Gibbon and Novas 2007; Jasanoff 2004; Lock, Young, and Cambrosio 2000). Cognizant of the issue of hierarchy of expert and lay knowledge, our attempt has been to be "attentive to the narratives that people construct to make sense of life: . . . how genomic data are conceptualized by the people under study and how local systems of knowledge may inform conceptual thinking in biology" (Pálsson 2008, 564).

In the end, our research was not only about the consequences of genetic knowledge for the students; it also had consequences for the geneticists and social scientists undertaking the research by exposing them to viewpoints outside their own areas of specialization. We found that conducting collaborative anthropological and genomic research required "connecting multiple epistemologies" (Egorova 2008, 560). As we have seen, this paper is the result of a scientific study carried out by intentionally multidisciplinary partners who shared a lively concern with better understanding the relationship between race, genomic science, social conceptions, and politics in contemporary Brazil. Each stage of the project required constant negotiation between "two cultures," that is, building bridges between anthropology and genetics (and between anthropologists and geneticists; Goodman, Heath, and Lindee 2003). At the core of our study is a fundamental duality between the truths of scientific genomics and the truths of anthropological subjectivities.[13] Our engagement with that duality resonates with Pálsson (2008) when he writes about "an explorative exercise, seeking connections between ethnographic and theoretical spaces normally kept separate" (Páls-

son 2008, 546). Within that complex epistemological landscape, we offer this example of methodological design and interdisciplinary collaboration in the context of the rapidly evolving interface between anthropology and human genomics.

Acknowledgments

Comments

Deborah A. Bolnick
Department of Anthropology, University of Texas at Austin, 1 University Station C3200, Austin, Texas 78712, U.S.A. (deborah.bolnick@mail.utexas.edu). 15 IV 09

Many studies have explored the relationship between race and biology in recent years, but this article provides an especially good example of the complex interface between color/race, ancestry, and genetics. Santos et al.'s research with the CEFET students in Rio de Janeiro, Brazil, illustrates the ways in which color/race and genomic ancestry are both connected and disconnected, and their analysis shows that collaborations between social scientists and geneticists are necessary for us to fully understand the complexities of this relationship.

For example, one of the primary findings of this study is the disconnect between perceptions of color/race and estimates of genomic ancestry. As Santos et al. note, the poor correspondence between color/race and genomic ancestry has been observed in previous Brazilian studies (Parra et al. 2003; Pimenta et al. 2006), but what sets this study apart is the detailed analysis of (*a*) how the research subjects themselves understand the lack of correlation, and (*b*) its relevance to broader scientific, national, and international debates. This approach makes it possible for Santos et al. to show how multiple sociopolitical factors shape popular understandings of color/race and contribute to the disconcordance between

13. We bring up this point prompted by the comment of one of the reviewers, who wrote about what he/she called "a fundamental duality in the conception of the research itself." For this reviewer, this duality expresses itself even in the format of our paper, which is "functional even if it gives it a positivist aspect." This comment reminded us of the long hours we spent struggling over what would be the most appropriate format for a paper jointly authored by social anthropologists and population geneticists.

color/race and genomic ancestry. In addition, by considering the genomic ancestry data in the context of broader issues (such as national discussions about the "natural" equivalence of blacks and browns), Santos et al. are able to shed light on other discrepancies between sociocultural views about biology and the actual patterns of biological variation. Their insightful analysis required both anthropological and genetic expertise, and it demonstrates the importance of interdisciplinary collaboration as we strive to understand the significance and implications of genomic research.

While the results of the genomic ancestry tests for the CEFET students call attention to the differences between color/race and genomic ancestry, this study also shows that the two are not entirely disconnected. Santos et al. tried to avoid imposing an a priori racialized view of the world by asking the students to define their biological ancestry by geographic origin rather than race. However, the students' comments indicate that they interpreted their genomic ancestry estimates within a racialized worldview and saw the different genomic ancestry components as *racial* ancestries. This interpretation is not surprising given the close correspondence between the geographic origins/parental populations that Santos et al. defined in their genomic ancestry model (Europe, Africa, and the Americas) and the three races (European, African, and Amerindian) in the founding myth of Brazilian nationality (DaMatta 1981; Freyre 1933; Fry 2000). These similarities, as well as the students' comments, suggest that this dominant narrative of Brazilian history (i.e., Brazil as the product of admixture between three discrete ancestral populations) has shaped understandings of both race and genomic ancestry. It might be interesting for this interdisciplinary group of researchers to further explore the role of this and other cultural narratives in structuring scientific models and genetic research in Brazil.

It would also be interesting to compare the Brazilian investigations of genomic ancestry and color/race with similar studies elsewhere. In the United States, for example, the relationship between race, ancestry, and genetics is equally complicated. Scientists in the United States, like Brazilian ones, generally use the term *ancestry* to refer to the geographic region(s) where one's biological ancestors lived (REGWG 2005). Genomic or "biogeographical" ancestry is therefore seen by many as being distinct from U.S. race concepts, which encompass geographic origins, political history, socioeconomic status, culture, skin color, and other perceived physical, behavioral, and genetic characteristics.

However, some geneticists explicitly connect genomic ancestry and race by defining ancestry as one's racial group or the race of one's ancestors (Frudakis et al. 2003; Risch et al. 2002). The geographically defined parental populations in genomic ancestry models can also be remarkably similar to U.S. racial categories, which leads to interpreting genomic ancestry data in ways that reflect (and reinforce) U.S. racial views (Bolnick 2008). Because both emphasize continental geography (even when clear biological support for *continental* divisions is absent), U.S. understandings of race and genomic

ancestry may have been influenced by the widespread cultural belief that continental groupings are biologically significant (Bolnick 2008). The relationship between color/race and genomic ancestry therefore appears to be similarly complex in Brazil and the United States.

In the United States, however, some studies show a strong correspondence between genomic ancestry and self-reported race/ethnicity (Tang et al. 2005). Such results stand in marked contrast to the findings of this and other Brazilian studies, and more research is needed to account for the difference. Because possible factors include differences in the number and type of genetic markers, the use of different models (admixture vs. no admixture) in the *structure* analysis, and differences in how race/color are determined in each country, interdisciplinary collaboration between anthropologists and geneticists will be key as we attempt to make sense of these conflicting results.

Rebecca Cann
Department of Cell and Molecular Biology, John A. Burns School of Medicine, University of Hawaii at Manoa, Biomed T-514, 1960 East-West Road, Honolulu, Hawaii 96822, U.S.A. (rcann@hawaii.edu). 27 IV 09

In a hyperconnected world, the word *race* heaves so many bombs that evolutionary biologists often try to avoid its use in any discussion about humans. I work at the intersection of genetics and human evolution, where the phrase *ancestry informative markers* is the current stand-in for race. How many of them are there, are they truly useful for any biological purpose, will they stand up to validation with nonproprietary databases, and do they carry any real information? These are the questions backing up National Institutes of Health grant applications with billions of dollars at play. One estimate is that 30–50 well-positioned markers can identify an ancestral homeland for purposes of characterizing the population gene pool from which a person's DNA sample likely originated. The drive to find major genes controlling the development of facial features, funded in part by the Department of Defense, represents an even further application of this technology to ancestry genotyping and prediction of likely phenotypes associated with unknown DNA samples.

In the Honolulu of 1987, the cosmopolitan U.S. city touted as a racial rainbow, a street vendor questioned my purchase of a rice paddle. How would a Haole know what this should be used for? Why would I want one? She refused to sell it to me, and I was at first perplexed, then aggravated. This was my introduction to racial prejudice as a minority in a state made up of minorities. Because we now have a U.S. president who experienced this same social stew, any study that looks at how people identify their biological ancestry in a changing context of information and affinity is likely to provoke stimulating commentary. Brazil, our other multicultural rainbow example, serves it up.

In the United States, multiracial backgrounds are now sud-

denly visible and celebrated, although just 50 years ago they were still illegal in many states. The paper here by Ricardo Ventura Santos and colleagues touches numerous taboos. We now write laws to codify our notions and behaviors concerning ancestry and who owns it as NAGPA controls official discourse on the past. However, my cultural identification as a Hawaiian—even speaking the language, but with no ancestral genetic claim—opens some splinter of concern. Indeed, the U.S. Supreme Court has been asked to rule on admission of nonbiological Hawaiians into a Hawaiian-preferred educational institution. If race is just a social construct, what are we essentially denying by refusing to recognize that we primates really use a visual system to identify kin and close relatives? And, once language intervened, is what we say to each other more informative of our intentions than what we seem to say, based on visual inspection? Is this honest signaling system the basis of social unrest?

For the Charles Darwin celebration this year, in recognition of his insight and humility, many have sought to codify his most significant contributions to understanding humans and their place in this modern world. My favorite commentary is that of a hip-hop performance artist/philosopher, Baba Brinkman. His Natural Selection excerpt from the Rap Guide to Evolution has students chanting with him "I'm an African" (http://www.genomeweb.com/blog/chuck-d-indeed). When reduced to essentials, poetry conveys a core of knowledge felt emotionally and conceptually. The value of Santos et al.'s article is its illustration of how genetics both challenges and encapsulates the experiences of all of us today.

Francisco R. Carnese
Sección Antropología Biológica, Instituto de Ciencias Antropológicas, Facultad de Filosofía y Letras, Universidad de Buenos Aires. Puán 480 of. 407 (1405), Buenos Aires, Argentina (antbiol@filo.uba.ar). 25 III 09

The aim of Ventura Santos et al.'s research was to analyze in young students the perception they have of their color/race and to compare this information with the biological/genetic data obtained from the analysis of 40 biallelic short insertion/deletion polymorphisms (INDELS). The study was conducted at the Centro Federal de Educaçao Tecnológica de Química de Nilópolis, Rio de Janeiro (CEFET/Chemistry).

The authors divided the work into four stages. In the first stage, students classified themselves, by means of open and closed questions, according to color/race. In the second stage, photographs and biological samples were taken for the genetic studies, and students answered a questionnaire on the perception they had of their ancestors. The third stage entailed making a new self-classification and a heteroclassification using the photographs taken in the previous phase. In the final stage, interviews and discussions were carried out on the perception of color/race, terminology and diversity of the classification systems, racism in Brazil and the school environment, and the relationship between the self-perception of their ancestors and the genetic results. Worthy of mention is the interdisciplinary approach of the study and the methodology used by the researchers, which allowed them to compare the information obtained at each stage of the study.

They observed that 20% of the students changed their own perception of color/race when the self-classification was compared in two opportunities over a 4-month interval. The same difference was noticed when the self-classifications were compared with the heteroclassifications made from the photographs, resulting in a clear tendency toward "whiteness."

They also found variances between the sociocultural perception that students have about their racial mixture, obtained from the analysis of their ancestors, and the data provided by the genetic tests. For example, the brown, who see themselves as having a considerable "racial" mixture, have more than 80% European genomic ancestry, the same as the white; however, the black, who see themselves as having a high African ancestry, are the ones that have more gene admixture.

The authors express concern about this matter because in certain strata of Brazilian society, there is a tendency to strengthen the concept of "racial identity" based on skin color, and, as proof of this, they cite "the Statute for Racial Equality, under discussion in congress and with government support, would include a person's 'racial identity,' using the IBGE census categories, on all personal documents, as well as in health, education, and police records."

However, if we accept that the data of the CEFET can be extrapolated to all the population of Rio de Janeiro, it is clear that it is not possible to uphold the existence of a "racial identity" based on phenotypic features such as skin color or on genetic characters. Regarding this issue, the authors should have discussed the concept of identity given the fact that biological determinism plays an important role in supporting these conceptions, placing historical, social, and cultural factors as determiners of identity of human groups in the background.

One cannot foresee the effect this article might have on certain strata of Brazilian society and in other countries with similar concerns, but surely it will open a wide debate not only of academic interest but regarding the development of public education and health policies. As to the latter, the Ministerio de Salud of Brazil stated that some of the health problems that the black population suffers—such as sickle-cell anemia, glucose-6-phosphate dehydrogenase deficiency, and foliculitis—are "genetically determined." The authors draw attention to the dangers of racializing genetic illnesses, which contributes to stigmatizing the black population. It is interesting to mention the comments of two members of Associação Baiana de Doenças Falciformes (ABADFAL), who on a visit to the city of Alagoinhas, situated in the interior of Brazil, saw three graffiti: "Anemia Falciforme. Doença de Preto. Transmissível. Cuide-së" (Calvo-González 2006).[14]

What influence can this type of study have on avoiding discriminatory attitudes and also on the vision the population

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14. "Sickle cell anemia. Disease in Black. Transmissible. Take care."

has of "races" and racism? If we take into account the appraisals of the students interviewed, most of them consider that these results will not change those conceptions in the short run; however, in general, they reckon that they will in the future. Nevertheless, it is important to highlight that these studies provide important information that, at least, withdraws biological support to racist arguments.

It would be interesting, for comparative purposes, to continue this type of research in other areas of Rio de Janeiro, with a different socioeconomic composition than that of the CEFET students.

Maria Cátira Bortolini
Departamento de Genética-Universidade Federal do Rio Grande do Sul, Caixa Postal 15053, 91501-970 Porto Alegre, RS, Brazil (maria.bortolini@ufrgs.br). 12 III 09

Homo sapiens sapiens descends from a long lineage of hierarchical animals for which life in groups is not an option but a survival strategy. Any biologist would classify our species as obligatorily gregarious (Waal 2006). Naturally, the ways in which these groupings are formed and maintained is not aleatory (because it is a survival strategy), being also characterized by the incorporation of many cultural elements that reinforce identity construction. The formation of both individual and group identities appears to involve an ongoing sense of "self" and the "other" in interaction with their social environments. Additionally, identity is constantly under construction and can be conceptualized as a complex, multifaceted process that produces a negotiated temporary outcome for the dynamic interplay between internal striving and external prescriptions, between self-presentation and labeling by others, between achievement and ascription, and between regulation and resistance (Ybema et al. 2009).

One of the most common points on which this debate has hinged is the question of the epistemological status of "race," with all its social and political implications. An expected premise is that new and recent social elements as genetic (or genomic) information about ancestry, as well as motivations based on national policies that promote social inclusion based on "race" or any other supposed discrete category, are incorporated in the construction of individual and group identities in modern contemporary societies. But this premise is only expected; there is an evident necessity to evaluate the real dimension of the phenomena in any human society.

With their elegant and very well-conducted interdisciplinary study, Santos and colleagues explore this thematic in the Brazilian context, widely known for a long time as different from others because of several historical and cultural particularities. Among them can be cited the notable and complex pattern of admixture between native people from different continents (America, Europe, Africa), as well as between their descendants. Recently, genetic data have demonstrated that the dimension of this admixture is higher than could be supposed considering morphological information only. It should

be mentioned that in Brazil, skin color and other anatomical features, rather than ancestry, has been traditionally used to define an equivalent to "race" (Parra et al. 2003). Concomitant with the celebration of the Brazilian mixed heritage and expanded beyond the skin-color perception through the new genetic knowledge, policies of the Brazilian government are encouraging notions of absolute "racial" identities, especially "black identity," to adopt public interventions favoring the "nonwhite group."

Although Santos et al. stress caution with their results because the investigated sample was restricted to young students from a Rio de Janeiro high school, the paper emphasizes for the first time the dynamic relationship between these recent and antagonistic views in the context of Brazilian national identity (trans)formation. Santos et al.'s study shows that although the idea that our identity can be revealed and measured by a genetic test is very attractive, the students did not passively accept the information that the genetic data revealed about "their" ancestry. For the majority, resistance was manifested when their view of a "racially" mixed person was confronted. This demonstrated that a "scientific fact" often cannot be adopted as a definitive proof of identity. Additionally, an "obvious discomfort" was described when the students had to categorize themselves by "race" or color.

These results emphasize that the official pressure to implement predetermined and dichotomic identities in Brazil could be unsuccessful, at least in a short-term period. It is great news, especially considering their implications, as in the clinical area (a priori typological categorization to use of a specific medicine). The political and policy decisions to confront social problems in Brazil should envisage other types of measures.

João de Pina-Cabral
Institute of Social Anthropology, University of Lisbon, Avenida A. Bettencourt 9, 1600-189 Lisboa, Portugal (pina.cabral@ics.ul.pt). 1 IV 09

There is much to praise in this courageous paper. Responding to an ongoing debate about the political usages of the concept of "race" in Brazil, the authors establish definitively that (*a*) phenotypical stereotyping is not a satisfactory way of predicting a person's actual physical heritage and (*b*) Brazilian modes of phenotypical stereotyping are not constituted in the binary black/white style that is one of the principal legacies of British colonialism wherever it dug its heels.

This having been established, however, it cannot be doubted that (i) phenotypical stereotyping has an extraordinary appeal to the incautious mind and (ii) phenotype is very often statistically associated to socioeconomic privilege. In the light of these, one can only surmise that phenotypical stereotyping is here to stay. In fact, in researching the genomic constitution of a student population in Rio, one could be sidestepping the issue behind the whole discussion: race—

not as defined in genomic terms but the category as it is *actually* used. Now, contrary to its earlier biological meaning, the concept is only being used today to describe one kind of phenotypical differentiation: "blackness." And this is not something that we can blame on popular culture, for we know very well that when New World social scientists discuss race, they too are invariably only speaking of "blackness." It is, furthermore, this concept that moves the whole gamut of policies of "affirmative action" that the *Partido dos Trabalhadores* has steadfastly been promoting. In Brazil, the semantic shift in the meaning of the concept from the old Portuguese notion of "color" (*côr*) started a long time ago, and what is being debated is precisely how it should continue to evolve.

The issue, then, seems to be what is the best strategy for reducing prejudice and socioeconomic discrimination in Brazil? After all, this is what made the authors undertake what they confess was a difficult exercise. Contrary to what authors such as Pálsson have been forecasting for decades, the agendas of the two anthropologies (biological and sociocultural) and the methodological paraphernalia each of them conspires to use have continued to diverge. Successful examples of collaboration between biologists and social scientists such as this one, actually leading to results that are meaningful to both, are few and far between.

Thus, we have to conclude that the problem of race is of a political nature. In the face of the patent semantic evolution that is occurring in the concept of race, two polar strategies offer themselves. (*a*) Do we opt for reinforcing the category by positively revaluating the history of the descendants of African slaves? This was Herskovits' strategy. Or (*b*), do we deny the validity of the category, stressing that phenotype is a poor predictor of actual genomic constitution? This was Freyre's strategy.

Whatever happens, any meaningful response must contemplate how race is constructed locally in each case, for this varies considerably. Wherever a binary system of ethnic differentiation has given rise to a category of "blackness" that determines collective action in a univocal way, a Herskovits-type option seems adequate. To the contrary, wherever the dominant category is "color" (i.e., a graded classification that does not determine on its own any form of collective action or access to privilege), the Freyre solution seems to be wiser. The implementation of a Herskovits strategy to a color-type situation is a dangerous thing, for it can only contribute to the consolidation of phenotypical stereotyping, thus going against the ethical aims that everyone agrees on. In short, the active promotion of "blackness" as a trope for collective action and apportionment of privilege has implications in Brazil that it does not have in the United States, for it is likely to promote phenotypical stereotyping and the ensuing racial prejudice.

On the whole, people whose sensibilities have been marked by Lusophone cultures tend not to favor Herskovits-type solutions, for they tend to see ambiguity in phenotypical classification as a source of personal freedom, reducing the effects on individual agents of ethnic discrimination. As it is, how-

ever, in spite of this study's results, it remains uncertain to what extent it is still possible to avoid the increasing consolidation of "blackness" as a univocal category of ethnic belonging in Brazil, because it is being promoted by very powerful ideological forces, not least of which the Hollywood movie industry. In Bahia, for one, the movement has gone very far in affecting public opinion. Policies such as that of racial quotas for university entrance may only be the tip of the iceberg of a cultural change that is ongoing. This having been said, it also does not seem likely that the long-term characteristics of Brazilian society will simply be wiped out because of today's passing global hegemonies. So, probably, some sort of combined strategy is the right one to address what everyone agrees on: the need to reduce racial prejudice and socioeconomic discrimination.

Sahra Gibbon
Anthropology Department, University College London, 14 Taviton Street, London WC1H OBW, United Kingdom (s.gibbon@ucl.ac.uk). 15 IV 09

This is a timely and original contribution to the current debates across the social and natural sciences regarding the implications of novel understandings of human genetic variation for identity and health. Taking a clearly defined multimethod research project that conjoins sociocultural and genomic analysis to explore the meaning of race classification in Brazil, it is an important addition to an expanding field of inquiry. Where heated and sometimes unproductive debate ensues across and within disciplinary fields on these issues, this study provides us with a powerful exemplar of the utility and value of reflective cross-disciplinary engagement. As such, this collective endeavor is a significant and important starting point for productive discussions that can move debates forward.

My comments concern the contribution the paper makes to two related yet slightly separate issues: first, the authors' engagement with the concept of biosociality, and second, the scope and limits of collaborative or interdisciplinary research or what has been described as biocultural anthropology (Goodman, Heath, and Lindee 2003) or genomic anthropology (Pálsson 2008).

Social science examination of the way developments in genomic and other health technologies have implications for concepts of identity and personhood have expanded in recent years. Work in sociology and anthropology is beginning to provide us with better understanding of the varieties of biosocialities that new biological knowledge can engender. This also includes situations where there is a lack of fit between identity, identification, and genetic knowledge. Comparative research of different disease conditions and work outside European-American societies has proved particularly important in revealing the space and shape of these diverse meeting points. Exploring how young Brazilians respond to and reflect on the results of genomic ancestry testing in the context of

self/other classification as this relates to skin color and "race," the study illuminates the space of biosociality in some very particular ways. It both usefully extends the project begun by Celeste Condit examining how "lay" publics located outside of health care arenas perceive or engage with genetic knowledge (see Condit et al. 2004) and chimes with more recent efforts to consider how new knowledge of human genetic variation is intersecting with "older" forms of classification, based in this case on race and skin color. While the findings of the study point to the relative unimportance of genetic information for the students, the malleability of self/other identification in Brazil (also usefully illuminated by the research) suggests there is potential here for a more flexible mobile terrain of biosocial identification. Although extrapolating from the specific findings of the study should, as the authors acknowledge, be done with caution, important questions are raised by this data. This includes whether, in a political climate where controversial policies of inclusion have emerged, different Brazilian publics (or even the same research subjects engaged in a different study at a different time) perhaps more invested in genetic information related to ancestry—whether for health-related reasons or because they have more to gain from the controversial quotas in accessing higher education—attribute a different significance to biological information. The problematic issue of relevance in extending findings is of course a common one, yet the very clearly delimited parameters of the study nevertheless raise this issue. Other questions relate to the innovative alignment between the biological and the social in the design of the project.

One of the most valuable aspects of the study's interdisciplinary dimension is the critically reflective eye it casts on the problematic methodological issue of sampling in genetic research. By contrasting and comparing different approaches to classification, the paper opens up a highly productive space for cross-disciplinary discussion about what counts as evidence in social and biological studies of human difference and identity. Yet while offering the reader invaluable insight into how the students, the designated subjects of the study, read across and respond to social and biological "truths," we have only a few tantalizing glimpses of how the researchers themselves negotiated these different realities in carrying out the project. The reference to the research study as itself a "social laboratory," which aimed at "melting" disciplinary boundaries yet was still comprised by a "fundamental duality," says something important about the dynamic arena in which two different cultures collaborated. Yet the working space of interdisciplinarity remains something of a mystery, and the reader is perhaps left to read between the lines about where and how common ground, contradictions, or differences were manifested and resolved between the researchers themselves.

Working with the tension between mobilizing or enacting vital interdisciplinary research on genomics and identity *and* critical reflection of the value of such work in terms of what is gained, reframed, or lost will be a vital yet not necessarily easy requirement for fruitful collaboration between the social and natural sciences. The valuable and important "bridge" that has been built between genomics and anthropology in this paper suggests that a quest for absolute symmetry in such an endeavor is perhaps an illusory goal that should be supplemented by mutual commitment to evolving terms of engagement where shifting, sometimes uneven alliances across disciplinary cultures can yield unexpected productivity.

Alan Goodman
Hampshire College, Cole Science Center 104, Mail Code DO, 893 West Street, Amherst, Massachusetts 01002, U.S.A. (agoodman@hampshire.edu). 21 V 09

Ideological changes are difficult to recognize when one is in their midst. With that caveat, I suggest—rather than pronounce—that anthropologists and geneticists are reaching an ideological tipping point, a time when the pace of change increases and a threshold is crossed. Making predications is foolish, as the odds of being wrong are great, and on this one I have been wrong before (Goodman 2000). For the sake of experimentation, however, I predict that Santos and colleagues' paper may be part of the tipping point from a worldview in which race as genetics is seen as powerful to a worldview in which racial genetics are seen as a contrivance and disconnected from the lived experience of race. That is the first half of the tip. The second half comes later.

Let us first back up. A mere century ago, a fierce debate concerned how much race, at that time seen as natural groupings, explained differences in physical and mental capacities. Many of these debates, slightly modified, on genetic-race differences in drug resistance, athletic prowess, intelligence, and most anything else continue to this time.

A century ago, there was little concern that our ethnosocial identities would not map nearly perfectly onto phenotypes and genetic groupings. Today, that has changed. Satel (2002), in "I am a racially profiling doctor" argues that even if social race maps poorly onto genetic differences, it is the best we have, and we should continue doing so. Malik (2008) writes that biomedicine must be based on social groups and somewhat perversely that social policy ought to somehow be divorced from social race.

I suggest that two criteria needed to be met for social identities to be justifiably used as a proxy for genetic races. First, if we are to continue to tell universalistic stories about genetic-race differences, it must be shown that races are somewhat genetically homogeneous and stable. Second, with modest fidelity, one must be able to correlate social race identities with genetics similarities.

As Santos and colleagues explain, it became clear that the first criterion was not being met after Lewontin's (1972) famous study of the apportionment of variation, and it fails even further with a wide range of recent analyses that have confirmed and built up Lewontin by, among others, Long,

Li, and Healy (2009), Hunley, Healy, and Long (2009), Templeton (1999), and Yu et al. (2002). Yu et al. (2002), for example, show that the mean number of SNP (single-nucleotide polymorphism) differences between two Africans is just as great as the mean difference between an African and a European or Asian.

The contribution of Santos and colleagues is mainly in resolving the second criterion, how social classifications map onto genetic classification. We first learn from Santos and colleagues that the complex perceptual and ideological calculus by which individuals assign themselves and their acquaintances into race groups is unstable. Individuals change their own assignments within months; how they assign themselves may be influenced by their sense of which answer best suits their needs. This flexibility of social identities is fine, to a point, but becomes problematic when we try and hold it still so that we can use it as a proxy for genetic similarities in forensics and medicine. A while ago, Hahn, Mulinare, and Teutsch (1992) showed that in the United States, over 40% of babies that were classified as Native American on their birth certificates were classified as white on their death certificates less than a year later.

Santos et al.'s empirical observations on the flexibility of social classification provide a fine appetizer for the main course: the relationship between social and genetic classifications of race. Santos and colleagues show that individuals who self-classified as black, brown, or white differ rather little in their genetically calculated percent African, indigenous, and European ancestries (fig. 1). They overlap tremendously in their African Ancestry Index (fig. 2). I take away from this study that in one field location, a high school in Rio de Janeiro, there is little connection between social race and genetics. Before jumping to more global conclusions, I would like a little more information.

How appropriate are the methods used for genetically estimating continental ancestry percentages? Could another method have lead to a better concordance between social identities and genetic ancestries? What information suggests that this case can be applied to, for example, the United States? After all, Brazil is known for its mixing, whereas the United States is not.

Santos and colleagues leave us at the Boasian moment where we realize that race as genetics does not map onto social life, and indeed, it cannot and does not explain lived experiences. Rather than stop at the disconnection, let us tip the paradigm over entirely. Instead of genetic race as explaining race differences in wealth and health, perhaps we should be seeing social race as explaining these differences. In other words, we are reversing the causal arrow from biology causing the social to the social causing the biology. The lived social and political realities of a raced and racialized life get under the skin, cause stress and biological havoc, and lead to suffering and shortened lives.

Carlos López-Beltrán

Instituto de Investigaciones Filosóficas, UNAM, Circuito Mario de la Cueva s/n, Ciudad Universitaria, CP 04510, México D.F. (carloslopezbeltran@gmail.com). 21 V 09

This is a creative and intelligent piece of work that inserts itself within the series of exciting recent developments toward a critical genomic (or molecular) anthropology (Marks 2002; Palmié 2007; Pálsson 2008). It confronts the most important and challenging issues brought forth by the new genetics: the uncertain interactions it is generating between genomic discoveries and the identity and self-representation of individuals and groups. It does that in the context of a complex politically and ethnically structured population in which racialized physical difference plays a huge social role. It takes advantage of the strategic collaborative space that researchers in genetics and anthropology have managed to devise in the Brazilian scene. The deeply disputed historical and sociological landscape developed through the centuries in Brazil in relation to skin color, racial admixture, social class, and popular human typologies have recently been confronted by the results of series of ancestry- and admixture-probing genetic researches (Pena et al. 2000; Santos and Maio 2004). This scene brings forth the most acute and challenging questions with regard to racialized human populations and the role genomic tools should play in search of reasonable solutions. (Wade 2004).

The methodology of this work is aptly designed to tackle the conundrums generated by the introduction of revelatory (liberating or disturbing) reconstructions (narratives, theories) stemming from genomic labs in the midst of racially conflicted populations. The critical and ethical aim is to explore ways of dealing with conflicting representations and incommensurability of different kinds of values and knowledge regimes. The focus on a controlled, discrete population of Brazilian students capable of processing at an adequate level the meaning of genomic analysis and contrasting it with their experienced notions of skin color and race in their everyday lives opens the possibility of deeper exploration of conflict processing than is usually available in other ethnographic settings.

We gain with this work some insight into the alternative roles the new genetics is likely to play in the reshaping of human individual and collective self-awareness of historical, biological, and cultural identity. We also gain some clarity about how to judge the desirability of those roles within (and outside) historically constituted social and ethnic groups and about the very difficult theoretical, political, and ethical questions that we have ahead.

As all works in this young field, this one faces problematic conceptual and ethical questions. What exactly can (or should) a knowledge of the distribution of genetic variants in human populations do for us both with regard to the knowledge of our history (ancestry) and our physical and mental dispositions (especially health related). Do we really require (and for what purposes) genetic criteria for generating

population partitions that ascribe different genomic identity to (genomically) different individuals or sets of them? What status should we give our "objective" genomic population substructuring when divergent and incompatible partitions can be had by changing previous assumptions?

Ancestry informative markers (AIMS) have been especially under criticism for opaquely narrowing down the possible ancestral origins and to overstating the weight of a few markers. (Bolnick et al. 2007; Palmié 2007; Pálsson 2007; Rosenberg et al. 2003). Also problematic is the depiction of "genomic ancestry" as somehow equivalent to traditional ancestry blood fractioning (remember quarterons, etc.?) by constructing its results in terms of percentages of three discrete ancestries. From gauging a few markers (each ranges of uncertainty), an extrapolation is made to build the 100% addition. So assertions such as "the students who classified themselves as white are predominantly European from the genomic point of view (mean 88.7%); in second place is African (7.2%); and in third place is Amerindian (4.1%)" are really difficult to understand as plain statements of fact, even if we know they are meant as expressions of complex probabilistic reasoning and not as essentialist in spirit.

Despite claims to the contrary, the research methodology in this work creates an imbalanced scene where "genomic ancestry" when contrasted to "perceived ancestry" is given the aura of truth and objectivity. I believe this imbalance is an artifact of the methodological depiction of the two types of ancestry under the same frame. The aim of commensurabililty is achieved by the use of percentages in both cases, but they are indeed two heterogenous constructs rooted in widely differing pragmatic spaces.

The concept of genomic ancestry has been partially shaped by some historical assumptions and by the pragmatics of the research. We have no access to a "real" and "complete" genomic ancestry. Probably this setting could have allowed fomenting in its young participants an awareness that science itself is also partially shaped by the questions we ask, the cultural elements we feed into it, etc., as well as by the standardized probabilistic methodologies we deploy to construct our results.

Cecília McCallum
Programa de Pós-Graduação em Antropologia, Universidade Federal da Bahia, Estrada de São Lázaro 197, Federação, Salvador, Bahia 40210-730, Brazil (cecilia .mccallum@uol.com.br). 15 IV 09

The concluding paragraph acknowledges the fundamental duality "between the truths of scientific genomics and the truths of anthropological subjectivities" to be at the heart of the study, asserting that their work engages this duality directly. From an anthropological perspective, this engagement is the most suggestive contribution of the article. It also adds welcome insights and nuances to the ethnography of race and racial identity in Brazil, a politically "hot" topic where every

new publication is launched into a mined battlefield. For supporters of affirmative action, the results of new genetic research on the origins of distinct population groups may be irrelevant or ideologically suspect, especially when used to argue against the political use of a socially based "race" concept. For opponents, genetic "truths" destabilize the binarization of race enacted by such policy making. But the controversy begs a deeper question, one that emerges from the very duality put to the test by Santos and his colleagues.

At stake during the research in CEFET/Chemistry was an unequal dispute over the epistemological status of science and of lay forms of knowledge—unequal because conducted in a context where a hierarchy of truth values gives science priority and scientists highest authority. Both researchers and "natives"—budding scientists themselves—are constrained by this hierarchy, notwithstanding differences in each group's modes of reckoning it. In Brazil, the struggle for "truth" ranges over distinct terrains—religious as well as scientific and medical. No single truth regime can be said to hold sway, of course, but scientific truths are taught at school, and new research findings are regularly trumpeted as such in the media. Much truth telling centers on the body in multiple aspects—raced, gendered, classed, infused with spirit, material, natural, constructed. It draws on interrelated sets of conceptual oppositions that fix the terms of debate and handicap those who would critique the hegemony of science as truth: a basic set links superstition/truth, irrational belief/scientific fact to traditional/modern. A second, related set contrasts rural/urban, uneducated/cultured, popular/middle class, and black/white (McCallum and dos Reis 2005). When subjects position themselves, they face the positive value normatively attached to the second term in each pair.

In this wider symbolic context and in the technoscientific setting of the school, informants would be inclined to give great value to the results of the genomic study. Confronted with a lack of fit between other, phenomenological truths expressed in terms of personal "race" or "color," and the results of genomic investigation, some felt intense discomfort. The composite category "race/color" used in interviews and questionnaires allows leeway for expressing personal truths because it vaguely suggests a fusing of heredity with appearance and scientific truth with experiential certainty. But this blurring is disallowed by genomic facts. The effect on subjects is to undermine the grounds for an apprehension of "truth" itself.

For the authors, the discomfort of their informants occurs in the dissonant space between two discursive fields: one the realm of myth (the nationalist construction of identity) and the other of genetic science, which tells the "real truth" about the origin (and sometimes the destiny) of bodies. It seems to me that we are speaking of a much wider set of phenomena than two (or more) discursive fields, because what is at issue is the epistemological foundation of the debate and the manner in which it relates to questions of ontology. To speak of origins—of the nation, of races, of bodies—is to conjure up

distinct and interrelated time frames in which such entities are generated. It is to evoke kinds of knowledge that are often distinctly experiential in nature. Harder to name and difficult to ascribe relative status, they include knowledge of kin relations, of family histories, and of ancestry and heredity and blood relationships—that is, of the way that known bodies participate in particular sets of origins and trace out possible destinies—their own and of others (McCallum 2008). It is these kinds of understanding that underlie the emotionally charged identities to which informants laid claim rather than dryer, more theoretical forms of knowledge. Although the authors acknowledge that they did not explore the relation of lay notions of genetics and race to kinship and relatedness in their study, they have most admirably opened the way for future research and discussion in this direction.

One final comment on a different note: with respect to the discussion of race in Brazil, the authors state that proponents of affirmative action based on bipolar racial identity are "largely influenced by the North American experience." However, there is clear evidence that binary thinking occurs independently of such activism (McCallum 2007; Sheriff 2001). As such, it is one among several possible indigenous approaches to racial difference in Brazil. But this is but a small aside and is not meant to detract from the overall value of this excellent article.

Gísli Pálsson
Department of Anthropology, Gimli, University of Iceland, 101 Reykjavik, Iceland (gpals@hi.is). 20 III 09

One of the fascinations of the modern era is that of DNA mystique and gene centrism. While gene centrism has its limits, and our genomes do not tell us who we are, DNA analyses increasingly inform subjectivities and social networks in many contexts throughout the world. Moreover, such analyses provide an important avenue into human history—along with the evidence of archaeology, linguistics, and folk narratives—for the simple reason that our genomes contain the signatures of our parents. For anthropology, as a result, the new genetics offers exciting challenges, an interesting site for exploring new socialities and an important opportunity to explore human variation, evolution, and history. The study of Santos et al. fuses the two dimensions of subjectivities and genomic variation in a productive manner in a given context, exploring "how sociocultural aspects of color and race among young Brazilians interrelate with dimensions of biology and genetics."

Given the antiquity of racial thinking and the popularity in recent years of population studies (and their implications for just about anything), it may be tempting to speak of the inevitability of race, a kind of basic-color-terms approach to human variation and well-being. Yet the color terms themselves are often fussy and shifting, constructed in particular contexts by people motivated by specific, temporary agendas.

Also, while the integration of the new genetics has rekindled interest in human variation—partly in the context of biomedicine–and significantly expanded our knowledge—raising new questions about how we differ from one another and other primates—in the process, genetic studies have redefined the old and highly contested issues of race and color, sometimes reintroducing them on new terms. While they have largely removed physical signatures such as skin color from the scene, by focusing on the properties of genetic markers, much depends on the ways in which genetic studies demarcate "populations." The exploration of genomic differences, therefore, is a tricky subject, politically and ethically charged, and subjects and contexts need to be handled with care. This is one important reason for integrating ethnography and genomics the way Santos et al. do in the four phases of their methodology.

The mixed four-phased methodology does a good job at eliciting statements about subjectivities and belonging. As the authors point out, such a multifaceted research setting provides a "social laboratory," a context for learning for both subjects and researchers. Interestingly, at some point they observed students engaging and resisting at the same time the themes they studied. It is important to continue to experiment along these lines with innovative tools and concepts for the purpose of exploring the extent to which folk terms of color and genomic analyses resonate or conflict with each other and how they may relate to politics of culture and race. Also, it is important to broaden the comparative horizon. As the authors say, while the kind of data they assemble may seem to pertain to only one country, in reality it touches on "theory and politics at the interface of race and ethnicity with the globalization of science and technology." Indeed, it would be interesting to explore the wider connections of immediate relevance to the case in question—beyond the school context to Brazil more generally, to South America, and to the Portuguese diaspora through Portugal, the Cape Verde Islands, Guinea Bissau, and Angola.

From the beginning, anthropology has usually been practiced as a two-sided discipline. On the one hand, it has focused on the comparative study of cultures and societies and, on the other hand, it has addressed the human body and its constitution, forms, evolution, and change. Recently, particularly with the new genetics and associated technical and theoretical development, the foundation on which this fragmented disciplinary landscape rests has been significantly altered. Not only have new labels (in particular, "genetic," "biological," "molecular," and "genomic" anthropology) entered the scene, competing with that of "physical" anthropology and sometimes relegating it to the sidelines, but also the dividing line itself between body and culture, always a little unclear, has been permanently blurred. It takes massive institutional and personal energy to maintain the divide against the winds of biosociality and the culturing of life, and often its use is both paralyzing and destructive to the scholars and the departments involved. The article by Santos et al. provides

a fresh take on this score, addressing at the same time the details of anthropological genetics and human variation and what people make of them in a specific ethnographic context. Few studies have managed, so far, to do so in a convincing way, but such projects are likely to become routine in the near future.

Livio Sansone
Programa de Pós-Graduação em Estudos Étnicos e Africanos, Centro de Estudos Afro-Orientais, Universidade Federal da Bahia, Largo Dois de Julho, Centro 40025-010 Salvador, Bahia, Brasil (sansone@ufba.br). 21 IV 09

This seminal article deals with the ways local systems of knowledge—and, if I may, local racial habitus—inform conceptual thinking in biology and its political use. I start this short commentary with a motto, which is that the article shows that DNA is a global icon with local meanings. This piece of work results from innovating collaboration between anthropologists and geneticists, in the text rightly defined as representing "two cultures." Hardly ever attempted before in Brazil, this mixing of academic cultures proved to be a highly fruitful experiment and produced a wealth of data on how young people in high school perceive color and race as well as the penetration of genomics and its jargon into daily life. The text also shows that popular understanding of biology (genomics) stands at the crossroad between three registers: scientific/academic cultures (which have produced terminologies and jargons of their own), the vertical transit of ideas between the analyst and the native point of view, and the horizontal transit of ideas between countries and regions of the world. If the vertical transit has often been phrased as the tension between high brow and popular understanding, the horizontal transit across space obeys the rules of globalization and the geopolitics of knowledge. Genomics, as the text shows, has powerfully entered daily life through its representation in the media; in the new fashion the establishment speaks of biology and, among others, in crime prevention—a highly tensed and politicized field in a violence-ridden country such as Brazil. Rather than through the traditional researcher-researched polarity in this field, information flows across a triangle: researcher–mass media/state–researched. Regarding the horizontal transit, Brazil, in spite of a long research tradition dating from the 1930s (after all the famous UNESCO project on race relations chose Brazil to produce empirical evidence for the famous Statement on Race of 1950–1953), has been thus far largely at the receiving end of leading notions of "race" in the social sciences. The article argues powerfully that in the case of the CEFET school in Nilópolis—I argue that a similar case can be made from Brazil in general—race is imagined from below very much in line with the way it has been imagined by the intellectual elites starting in the 1930s: Brazil is the epitome of racial mixture, and, deep down, each and every Brazilian is somewhat "mixed" even if he/she looks white. This mighty metaphor comes in different degrees—in lower-class as in upper-class versions, as a cry for (racial) equality or a warning against 'divisive' ethnoracial identities. Today's process of undoubted growth of the awareness of racial inequalities as well as the affirmative action that both results from this awareness and stimulates it, have to be rimed with this national metaphor. This is why one can have a country with more *negros* (the term that is used to express ethnoracial identity, as opposed to *preto* which, as the text points out, is just a term for a color) in spite of the higher degree of racial mixture when compared with one or two generations ago. Several surveys indicate that, contrary to the old saying that money whitens, over the last decade a growing number of brown Brazilians, especially among the young and educated, now self-identify themselves as black (*negro*). Ethnoracial awareness can apparently go hand in glove with racial mixture and its celebration in popular and intellectual discourses. If phenotype is not a good indicator of genetics, as Brazilian geneticists stress, it can certainly be an engine for popular genetics as well as for speculating or dreaming about our origin and ancestry. The research shows that in Nilópolis, being Amerindian and African—or, for that matter, Africa in itself— are positive icons: assets more than liabilities. Although the Amerindian origin of our nation has traditionally being praised by our elite, the celebration of African ancestry is, to such an extent, a newer and more widespread trend. This resignification of the icon Africa as well as being *negro* or *indio* from onus to bonus has been noticed in my recent survey among 414 households in the municipality of San Francisco to Conde, the region of Bahia most affected by the oil industry. I differ from the authors because I do not think that this new and growing ethnoracial identity among Brazilians results from affirmative action or the action of the state more generally. I see it, rather, as the result of a broader process that is making Brazilian society less hierarchical and unequal. Seeing black skin and 'Africa' as more beautiful and more part of ourselves than before is not yet, however, enough to turn Brazil into an "ethnic nation." That would require too much social engineering.

Peter Wade
Social Anthropology, School of Social Sciences, University of Manchester, Manchester M13 9PL, United Kingdom (peter.wade@manchester.ac.uk). 25 III 09

All over Latin America, geneticists are carrying out research about the "racial" or "biogeographical" origins of national populations as revealed through the genetic profile of sample populations (Wang et al. 2008) in an attempt to elucidate the genetic basis of complex traits, including disorders. The article by Santos et al. is a welcome and important contribution that takes a critical look at this trend; it is groundbreaking insofar as it is informed by the same kind of genetic admixture research that is the object of its critical attention.

The authors follow in the wake of researchers (such as Condit, Lindee, Brodwin, and others cited in the paper) who have examined the effect that expert genetic knowledge is having on nonexpert people (see also Franklin 2000, 2001). This research, in my view, points in different directions. On the one hand, the gene has clearly become an icon that facilitates biologically reductionist ways of thinking about people and behavior (Nelkin and Lindee 1995). On the other hand, it seems that people use genetic knowledge in strategic ways that may undermine determinisms and introduce contingency (Thompson 2005; Wade 2007). Santos et al. show this same strategic behavior among the students they sampled: genomic knowledge did not have a single direction of effect nor did it simply channel people into genetically determinist ways of thinking about themselves. Overall, the tendency was for students to minimize the importance of genetic knowledge: what mattered most was how other people perceived them racially, and the key cues here were racialized aspects of phenotype (skin color, hair type, facial features, etc.).

Some potential effects may emerge. For example, the tendency of people to emphasize Amerindian ancestry— which seems to be due to the place of the *índio* in the Brazilian national imaginary— is not reflected in their autosomal DNA markers, but it is reflected in their mtDNA markers. Might this strengthen the symbolic place of the *índio* and reinforce the imagined ancestral Amerindian mother figure, which is reappearing all over Latin America in the results of genomic research (alongside the African mother)? Might this, along with the low profile of African and Amerindian markers on the Y chromosome, reinforce the absence of the indigenous (and African) male in narratives of national origins?

The finding that the black/brown categorical alliance or fusion, which some statisticians have generated (Silva 1985, 2000) and which is reflected in state affirmative action programs (Htun 2004), is genomically not convincing also has an uncertain future. The authors recognize that this finding may be "secondary or even irrelevant" at the sociopolitical level, but they speculate that it might have an influence on state health programs that potentially could target a collective black (i.e., brown/black) category for health policies. If the finding has an effect anywhere, one hopes it would be on health policy, as genomics is important in influencing some aspects of health (yet the validity of a racialized genomics in shaping health interventions seems highly questionable to say the least; Koenig, Lee, and Richardson 2008). The possible influence of the finding on the political level is much more contentious. If genomic data are not very influential in how people identify themselves and others in race/color terms— as the data presented by Santos et al. suggest— then it seems unlikely that the finding will have much effect. Perceptions of racism, inequality, social justice, and national identity seem likely to have a greater influence. But this remains to be seen. Longer-term trends may show that genetic knowledge comes to have a significant political effect based in part on its status as science.

A significant methodological result is that classification by observers of self-identified browns pushes many of these people into other categories. This has implications for the black/brown fusion advocated by some statisticians on the grounds that self-identified blacks and browns suffer equally from racial discrimination measured statistically from census data (Silva 1985). Using such measurements to draw conclusions about relative degrees of discrimination needs to be done with caution, however, as discrimination is based on some people classifying others (e.g., as black or brown)—and Santos et al. show that self-identification and other-identification can diverge significantly in the case of browns. Thus, whites may be classifying as black some people who claim to be brown.

Reply

Rebecca Cann ends her commentary with the statement that our article illustrates "how genetics both challenges and encapsulates the experiences of all of us today." As we understand it, by "us" the geneticist is referring to a macrosocial context at the level of humanity itself. Perhaps we might argue that this "us" also applies, in a more limited way, to the authors of the commentaries. While the writers are social anthropologists, bioanthropologists, and geneticists, making up an interdisciplinary group that is theoretically diverse as well as geographically dispersed, each makes clear that genetics is woven into people's daily lives as well as pervading the theoretical reflections of biomedicine, the social sciences, and the humanities. We thank the commentators very much for their interest in exploring our ideas, which in many cases has resulted in reflections that go beyond the immediate context of our paper. In this short space we will try to address some questions that, we believe, permeate the commentaries as a whole, and also to respond to some criticisms (or requests for clarification).

Various commentators stressed the interdisciplinary dimension of our research effort. Peter Wade expressed particularly well the delicate and complex balance that guided our analyses: according to him, our work "is informed by the same kind of genetic admixture research that is the object of its [our] critical attention." Although practically all the commentators recognized this, some felt that we should have gone into more detail. For Gibbon, "the working space of interdisciplinarity remains something of a mystery, and the reader is perhaps left to read between the lines about where and how common ground, contradictions, or differences were manifested and resolved between the researchers themselves." In fact, we recognize that it would have been particularly valuable to examine further the methodological and epistemological differences that arose in the course of our work. The length of our article prevented us from exploring this aspect in more

depth (it was, literally, relegated to a note—see n. 13). However, we will use this response to give our readers an idea.

One of our objectives was to investigate the complementarities and tensions between culturally valued perceptions and those based on genomics. In order to do this, keeping in mind the kind of results that we would obtain from the laboratory analyses (genomic ancestry percentages) in phase II of the research, we designed a question for the CEFET students about how they perceived their biological ancestry. For a social anthropologist, taken in isolation, this style of inquiry might seem heretical. Or, as López-Beltrán points out, we placed in conjunction "two heterogenous constructs rooted in widely differing pragmatic spaces." Incidentally, the geneticist Bortolini in her comment, which might have been written by a social anthropologist, reminds us that "identity is constantly under construction and can be conceptualized as a complex, multifaceted process." In the course of the research, we took the opportunity to discuss these points and to reach a common denominator, agreeing that for reasons of comparison with other classes of data (e.g. with genomic ancestry), we would be addressing an extremely complex category using an approach involving, as we understood very well, a certain amount of simplification. On the other hand, the methodological design of the study involved other ways of capturing subjectivities, such as the interviews, the results of which were part of the interpretive framework of the study. In practice, as we read the commentaries, it appears that we succeeded reasonably well. More than the quantitative results in themselves, the methodological strategy, by interweaving different phases of the research, produced in the students' minds multiple contexts of explanation for their experiences.

The above example is one among many that we might mention. Incidentally, looking back, perhaps we should have followed up on an idea that we considered in an early phase of the proposal but that, for lack of resources and because of the complexity involved, we failed to implement. This would have been a further layer of research, with an investigator accompanying and observing ethnographically the research team itself; the relationships among members and with the research subjects (the CEFET students); laboratory practices, procedures of analysis, and exchange of ideas about the interpretation of results; and other topics. In other words, we might have produced, along the lines suggested by Bruno Latour (1987), an anthropology of science, a case study of our own "social laboratory in action."

There is another interdisciplinary aspect of the research that we should like to address. Pálsson writes that "it takes massive institutional and personal energy to maintain the [anthropological] divide against the winds of biosociality and the culturing of life, and often its use is both paralyzing and destructive to the scholars and the departments involved." Recently, in February 2009, after we presented some of the results of our CEFET study in a workshop on genetics and identity in Latin America at University College, London, the anthropologist Rayna Rapp, of New York University, inquired

how our study fits into the history and contemporary institutional makeup of Brazilian anthropology. There is no short answer, but for the purpose of this response, perhaps it is enough to say that modern Brazilian anthropology is very distant from the "four fields" model, with practically all anthropology departments consisting only of social anthropologists. In other words, contemporary Brazilian anthropology is not a product of the Boasian paradigm (see Goodman's comment) so influential in the United States. Therefore, our work did not originate from any institutional source that might (or might not) provide the stimulus for interdisciplinary interaction. The stimulus came, as we noted in the introduction to the paper, from the interest of a group of investigators in developing a interdisciplinary research project in view of the growing prominence of the interface between science (in the Brazilian context the popularization in the last decade of debates about biological ancestry, social identity, and its relation to the history of the country) and politics (current debates about color/race and public policies in Brazil, especially in the areas of health and education).

A number of commentators, especially Bolnick, Cann, Goodman, and López-Beltrán, discuss critically the uses and the interpretations derived from the utilization of so-called AIMs (ancestry informative markers). Recent critiques on the use of AIMs, like that of Bolnick et al. (2007), stress that it is inappropriate, given the present level of knowledge (sampling problems, etc.), to use molecular markers with the intent of identifying the specific locality of an individual's ancestral origin (e.g., West Africa, East Asia, etc.). Referring to this use as "recreational genetics," these authors point out that "the business of genetic ancestry testing" has become particularly popular among African Americans in the hope of "recaptur[ing] a history stolen by slavery" (Bolnick et al. 2007, 399). Therefore, one of the problems (and misuses) of AIMs is to try to identify an individual's ancestry at the microlevel. In our study, following Bastos-Rodrigues, Pimenta, and Pena (2006), we worked with a group of 40 INDELS aimed at identifying continental ancestry. The methodology was previously validated by studying an international panel of DNA samples containing 1,064 individuals from 55 worldwide populations.

Also referring to the uses of genomic ancestry, López-Beltrán's commentary touches on the issue of the different interpretations that can be derived from the way that quantitative data are presented. He considers problematic, and even "essentialist in spirit," what he calls "the depiction of 'genomic ancestry' as somehow equivalent to traditional ancestry blood fractioning . . . by constructing its results in terms of [the mean] percentages of three discrete ancestries." In contrast to López-Beltrán's reading, Goodman, in analyzing the graphics of our paper, does not see "fractioning" but a significant overlap in the indicators of genomic ancestry among individuals of the various color/race groups. How do we explain such different interpretations of the same results? The reason lies in the fact, as we learn in basic statistics, that the mean

is a very poor measure to describe the mathematical behavior of a variable because it gives us no information about the pattern of dispersion. In other words, any "essentialism in spirit" dissipates when we observe the graphics and the measures of dispersion (such as the standard errors of means in the tables) because, rather than separation, overlap predominates. It was never our intention to depict genomic ancestry as error free. As Stephen Jay Gould aptly pointed out, "the mystique of science proclaims that numbers are the ultimate test of objectivity" (1996, 58). In the case of the results of analyzing the ancestry of the CEFET students, if a simple (and simplistic) reading of the measures may give an impression of discrete and objective categories, analysis of the dispersion gives a much more fluid, even chaotic, picture of groups much less differentiated, far from a racialized view of human biological diversity.

In the same vein, Bolnick comments on how the categories used in the genomic analyses may lead to what she calls a "racialized view of the world." This is because, while we "avoid[ed] imposing an a priori racialized view of the world by asking the students to define their biological ancestry by geographic origin rather than race," in practice we limited their responses by asking them to state their perceptions of their ancestry in relation to one of three large groupings— Europe, Africa, and the Americas. We agree with Bolnick that in principle this formulation could be problematic, especially in the case of communities or societies that, from an emic viewpoint, have perceptions of origin not based on this tripartite division. This does not seem to be the case in Brazilian society nor in the specific community of the CEFET students, who share the myth of tripartite origin, or as we called it, "the founding myth of Brazilian nationality," or, in Roberto Da Matta's terms, the "fable of the three races" (DaMatta 1981). Beyond our specific study, or any others carried out in Brazil, Bolnick's comment has vital importance, because it warns us of the risks of projecting onto research subjects, in an uncritical way, structures that may be completely foreign to them in sociocultural terms.

A recurring point made in the commentaries—including those of Bolnick, Carnese, Goodman, Pálsson, and Sansone— is an emphasis on the need for comparative study, not only within Brazil but also internationally. In the Brazilian case, we ourselves indicated in the paper how we consider that extrapolations from the results must be made with caution, because the Brazilian population varies by region not only in particular genetic makeup (Alves-Silva et al. 2000; Carvalho-Silva et al. 2001) but also in color or race (IBGE 2007). Further research in other regions of the country would be important. In terms of race relations, there is a longstanding tradition of historical, anthropological, and sociological research comparing Brazil and the United States (Skidmore 1993). Therefore, we consider very relevant the suggestion by Bolnick and Goodman about the importance of comparative analyses along the lines proposed in our paper. No less important is Pálsson's proposal, and to a certain extent that of Pina-Cabral

and Sansone, that suggests analyzing cultural perceptions of ancestry vis-à-vis genomic results, taking as reference the context of the diasporas resulting from Portuguese colonialism, thus promoting south-south dialogue as well as the traditional north-south.

Gibbon mentions that she considers our work a "critically reflective eye . . . on the problematic methodological issue of sampling in genetic research." As we pointed out in our discussion, one of the impulses of our research effort was the observation that population genetics studies in Brazil have been carried out with great methodological diversity (from autoclassification to heteroclassification of subjects), and often results are compared without considering that the classification systems are not necessarily comparable. Beyond the different classification methodologies, there is the fact that the system over time may be unstable, as Goodman mentions in his commentary.

As Serre and Paabo (2004), with other authors, point out, the design of genetic population studies may strongly influence the conclusions derived from them. According to Gibbon, "by contrasting and comparing different approaches to classification, [our] paper opens up a highly productive space for cross-disciplinary discussion about what counts as evidence in social and biological studies of human difference and identity." We tried to explore, in spite of the small sample, the differences that might emerge from using autoclassification versus heteroclassification. We argued that the differences could be particularly striking in some regions of Brazil, such as the north, where a large majority of the population sees itself as brown, which is the group that shows the greatest difference when we compare the two systems of classification. Goodman, along with Wade, calls attention to a particular aspect of the color/race classifying system; that is, "individuals change their own assignments within months." In other words, there are diachronic as well as synchronic aspects that must be considered. It should also be pointed out that not only individual classification may change but also that of the Brazilian population in general. Analyses carried out by the IBGE show that the percentage of browns in the Brazilian population increased from 21.2% in 1940 to 38.5% in 2000 (IBGE 2007) This increase is probably due in part to the growing number of interracial marriages (Telles 2004). Nevertheless, it is certainly also influenced by the ideology of Brazil as a mixed-race country, which became increasingly influential during President Getúlio Vargas's regime, from the 1940s on (Fry 2000, 2005; Skidmore 1993).

McCallum commented on an aspect of our research that was not covered in our paper, but is certainly relevant: we carried out the research in a social space (a school) where "an unequal dispute over the epistemological status of science and of lay forms of knowledge" prevails. In future comparative studies, this is a point to consider (see Baran 2008). In any case, the ethnographic data suggest that the students are more concerned with the personal contexts and goals of their lives than with a "scientific" viewpoint. Moreover, as we

pointed out in our paper, unfortunately our research design did not include investigation of the students' preexisting notions of blood, kinship, genetic inheritance, etc. We wish we had collected these data, which would have been very useful to interpret our findings. We agree with McCallum that "it is these kinds of understanding that underlie the emotionally charged identities to which informants laid claim rather than dryer, more theoretical forms of knowledge."

In her commentary, McCallum disagrees with our statement that the emphasis of race-oriented social movements in Brazil on biracial identity is "largely influenced by the North American experience." McCallum cites the work of Sheriff (2001) in a Rio de Janeiro shanty town, as well as her own in Salvador (McCallum 2007), indicating that bipolar models are part of "indigenous approaches to racial differences in Brazil." We do not feel that our argument necessarily contradicts McCallum's. When we refer to the influence of the North American bipolar model, we are not denying the possible existence of bipolar perspectives in certain territories and contexts in Brazil (although the idea of a continuum is certainly more widespread). We are calling attention to the fact that in promoting public policies with a racial dimension at the national level, social movements invoke and build their arguments under the influence of the international scene where the North American weight and presence are unquestionable (see Fry et al. 2007a).

Sansone raises another point of disagreement in affirming, "I do not think that this new and growing ethnoracial identity among Brazilian results from affirmative action or the action of the state more generally. I see it, rather, as the result of a broader process that is making Brazilian society less hierarchical and unequal." The crux is, what is behind this "broader process"? Evidence shows that in recent years, the Brazilian government has played an important and influential role in implementing public policies promoting racial identity in Brazil. One of the most striking examples is the mechanism for admission to the universities through racial quotas. The case of the University of Brasilia, which has been analyzed by two of us (Maio and Santos 2005), is emblematic. Starting in 2004, a quota system was implemented at this university that involved for those applicants who declared themselves to be "negro" (a category that combined brown and black) having a photograph taken that was later analyzed by a university selection committee. If the committee did not find the candidate in the photograph phenotypically negro, an interview followed. As Maio and Santos (2005) describe, among the questions posed by the committee was one asking whether the candidate had participated politically in social movements involving race. These authors refer to "racial pedagogy" in the sense that to be a student admitted under the racial quota involved political and racial alignment. Fortunately, after intense national debate during which the system adopted by the University of Brasilia was even called a "racial tribunal," changes in the criteria were made. But the point that we wish to emphasize here is that the actions of institutions and agencies linked to the government have promoted in numerous ways the strengthening of ethnoracial identity (see Fry et al. 2007a).

Various commentators referring to our discussion made their own observations concerning the sociopolitical implications of the findings of our study. We tried to be very careful to avoid the interpretation that we were suggesting that biological data should necessarily inform social and political dimensions. In view of comments, especially those of Goodman, Pina-Cabral, and Wade, we conclude that we succeeded; that is, we were sufficiently cautious. On another dimension of the relation between science and culture (or biology and society), Pina-Cabral comments on the possible interface between reflections about the genomic ancestry of the Brazilian population (and relation to color/race) and "founding fathers" of social thought, in this case Herskovits and Freyre. Pina-Cabral is not referring to direct relations but to how new information about perception and biological ancestry may help us to revisit the ideas of classic authors.

In conclusion, we tried to show in our study how permeable are the borderlines between biology and culture and between genetics and identity and how fundamental it is to make borderlines between disciplines interpenetrable. More satisfactorily at some times and less so at others, we have tried to give equal weight to theories and methods derived from epistemologically diverse areas of study that rarely converse together to reflect about the everyday experiences of human societies. It is intriguing to note that in this debate, which turns on the central topic of identity, it would be very difficult, if they were not signed, to identify the disciplinary affiliation of the commentators. We have geneticists writing about the fluidity of identity and social anthropologists reflecting on the weight of the presence of genetic markers on origin narratives in Latin America. We should like to believe, with Palsson, that projects that blur disciplinary borders in the fields of genetics and anthropology will "become routine in the near future." To that effect, we hope that Goodman's prevision, which seems to be inspired by a Kuhnian perspective, may be correct, that "anthropologists and geneticists are reaching an ideological tipping point, a time when the pace of change increases and a threshold is crossed."

—Ricardo Ventura Santos, Peter H. Fry, Simone Monteiro, Marcos Chor Maio, José Carlos Rodrigues, Luciana Bastos-Rodrigues, and Sérgio D. J. Pena

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