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The Human Genome Diversity Project

An Address Delivered by

Luca Cavalli-Sforza
Stanford University

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THE HUMAN GENOME DIVERSITY PROJECT

LUCA CAVALLI-SFORZA
Professor of Genetics, emeritus (active)
Stanford University, Stanford, California, U.S.A.

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The Human Genome Diversity Project (HGD Project) is an international anthropology project that seeks to study the genetic richness of the entire human species. This kind of genetic information can add a unique thread to the tapestry of our knowledge of humanity. Culture, environment, history, and other factors are often more important, but humanity's genetic heritage, when analyzed with recent technology, brings another type of evidence for understanding our species' past and present. The Project will deepen our understanding of this genetic richness and show both humanity's diversity and its deep and underlying unity.

The HGD Project is still largely in its planning stages, seeking the best ways to reach its goals. The continuing discussions of the Project, throughout the world, should improve the plans for the Project and their implementation. The Project is as global as humanity itself; its implementation will require the kinds of partnerships among different nations and cultures that make the involvement of UNESCO and other international organizations particularly appropriate.

I have spent most of my career studying human genetic diversity, and I am the chair of the International Executive Committee of this proposed Project. In my talk, I will briefly discuss the Project's history, describe the Project, set out the core principles of the Project, and demonstrate how the Project will help combat the scourge of racism.

A Short History of the HGD Project

The Human Genome Diversity Project began, formally, in 1991. It resulted from my interaction with Allan Wilson, professor of biochemistry at the University of California, Berkeley. Allan was responsible for the most interesting developments in the evolutionary analysis of mitochondrial DNA. My own involvement in the study of human evolution began in 1951. Allan and I began collaborating in 1990, through the offices of Mary-Claire King, professor of genetics at Berkeley who had graduated with him in 1975 and who collaborated with me in the early eighties. The three of us, along with Charles Cantor and Bob Cook-Deegan, a historian of the human genome exploration, published an appeal in *Genomics* in 1991, making known to molecular geneticists the need for a systematic study of the human species. Sir Walter Bodmer, director of the Imperial Cancer Research Fund of London and a long-time collaborator — we wrote together two relevant books, *The Genetics of Human Populations* and *Genetics, Evolution, and Man* — was at the time Chairman of the international Human Genome Organisation, HUGO. In this capacity he named a committee to foster the development of the Human Genome Diversity Project, which I was asked to chair. Unfortunately, Allan Wilson died soon after.

In the fall of 1991, I convened a meeting at Stanford of professors Ken Weiss, Marc Feldman, and Mary-Claire King (we kept in touch with Ken Kidd by phone) to discuss applying for funds with which to organize workshops designed to plan the activity of the HGD Project. Funds were obtained through the U.S. National Science Foundation, with

the National Institutes of Health and the U.S. Department of Energy also participating. Various aspects of the project were discussed in four meetings:

1 July 1992, Stanford, California — populations genetics and statistical aspects;

2 October 1992, Pennsylvania State University, Pennsylvania — anthropological aspects;

3 March 1993, Bethesda, Maryland — molecular, biological, and ethical aspects; and

4 September 1993, Alghero, Sardinia, Italy — first international meeting, and formal constitution of the organs of the HGD Project: International Executive Committee, Regional Committees, and International Forum.

These workshops have helped give substance to the goals and methods of the HGD Project. Their conclusions are described below.

In addition to these formal planning meetings, the Project has been discussed in many other settings. In the first South-North Human Genome meeting sponsored principally by UNESCO in May 1992, held in Caxambu, Minais Gerdis, one day was dedicated to Human Genome Diversity. It was the subject of a U.S. Senate hearing, convened by Senator Daniel Akaka of Hawaii in April 1993. It was also the subject of a special symposium of anthropologists, convened in November 1993 by the Wenner-Gren Foundation. In January 1994, HUGO (the Human Genome Organisation) formally adopted the Human Genome Diversity Project as one of its projects. In May 1994, I met in Paris, along with Professor Henry T. Greely, chair of the ethics subcommittee of the North American Regional Committee of the HGD Project, with Justice Noëlle Lenoir and others to discuss this Project. Throughout the past several years, representatives of the Project have met with many different groups interested in this topic.

Main Decisions Taken at the Meetings of the HGDP

From the outset, the HGD Project has been planned on a global basis with worldwide coordination of sampling and testing. Local participation in all areas of the world will be essential and the success of the project will also be entirely dependent on international collaboration and cooperation.

It is recognised that not all regions of the world are experienced in the techniques of molecular biology and genetics and that some countries will not, in the foreseeable future, acquire the "cutting edge" technology that is needed for the mapping and sequencing work of the Human Genome Project. However, it is feasible for the more limited technological demands of the HGD Project to be met by most countries, given training of laboratory staff and help with techniques. One of the exciting aspects of the HGD Project is that it offers all countries a unique opportunity to become involved in, and contribute to, the global human genome initiative by undertaking the collecting and typing of samples from their own region as well as other studies of local interest.

At the first workshop, in Stanford in July 1992, population geneticists and statisticians were invited to discuss questions of scientific feasibility and sampling. Two main conclusions were reached.

(1) Samples should be taken from about 400–500 "populations," a term indicating ethnic groups defined by a self-imposed name, chosen by some criteria that would make them representative of the world's populations. An alternative sampling criterion championed by Wilson — namely, taking single individuals at regular geographic distance from each other

— was not completely excluded, although it was acknowledged that it presents practical difficulties.

(2) Two types of samples from each population are needed.

(a) From a smaller number of individuals (about 10 to 50, possibly 20–25), blood samples would be taken rapidly to nearby laboratories where white cells could be transformed, to grow in test tubes and produce DNA for the analysis of genetic material. This would ensure that material for biological study would be available for indefinite periods of time.

(b) From a larger number of individuals, 100–200 persons, small amounts of blood or other biological fluids like saliva or specimens like hair are to be collected, from which smaller, finite amounts of DNA would be available for studies that statistically require larger numbers of individuals from each population.

This work allowed us to form a first estimate of the cost of the project. Most of the specific expenses would be due to collecting the samples and preparing transformed cell lines. The latter are estimated to cost about $500 per individual; with 10,000 cultures to be made in a period of, say, 5 years, for a total cost of about $5 million. It is anticipated that the collection of samples would cost about the same. It is more difficult to estimate the cost of testing (that is, of ascertaining the DNA variation among the sampled people); this is open-ended, since the material should be available for a long time and stimulate interest in new genetic markers as they develop from future research. It was estimated that the costs of testing and of administration might bring the total for 5 years to the order of $25–$30 million. This is about 1% of the anticipated cost of the Human Genome Project itself, which is now under way and which, as is well known, does not plan to study more than one genome; that is, the Human Genome Project, unlike the Diversity Project, will not include variation. It is a modest cost, compared with the majority of biological projects.

The second workshop, at Penn State, considered which coverage of the world's genetic variation was most appropriate. The scope of the exercise was to record examples of populations that were considered of special interest by anthropologists. Since that time, we have decided to broaden our investigations. For instance, we found that African-Americans have considerable interest in their origins, which are usually unknown since relevant historical information is difficult to find. In fact, African-Americans in the United States had started independent research on the subject. We would like to include in our research all ethnic groups who declare an interest in our work.

The third workshop, at Bethesda, Maryland, considered technical and ethical problems. There is little worth reporting here on the former; the latter are the main subject of the present talk, and considerations suggested by the discussion at the workshop are incorporated in the balance of these remarks.

In the fourth workshop, held at Alghero, there was for the first time a representation from 24 different countries. It was decided to enlarge the International Executive Committee to include representatives from India, Africa, and Japan. It was decided that there should be an International Forum, in which funding agencies would be represented and each region would be represented by one or more members. Regional committees should form of their own initiative. The European regional committee was already in existence and has been funded by the European Economic Community since 1992. It has elected Sir Walter Bodmer as its chairman. In the course of the last years, other regional committees have begun to form. A North American committee has formed and met twice at Stanford, in January and in August 1994. Its chairman is Professor Ken Weiss of Pennsylvania State University, and it is the only region so far to have proposed bylaws for its own functioning. A

South American Committee has been formed, with Professor Sérgio Pena in the chair. A Chinese committee has been formed, with Professor Du Ruofo of Beijing Academia Sinica in the chair. Other regional committees are forming in other parts of the world.

The International Executive Committee met in Alghero, for the first time, and on September 16, in London.

Specific Aims, Design, and Methods of the HGDP

The HGDP is a project designed to take a sample of the human species for the purpose of genetic study of individual variation. The number of individuals to be sampled will be between 10,000 and 100,000. For most of these individuals, very small quantities of their genetic material, DNA, will be stored in suitable repositories; for a smaller fraction, perhaps 10% of individuals, a more permanent source of DNA will be stored, in the form of transformed cell lines. This is a well-tested method for the conservation of live cells for indefinite periods, under conditions in which they can multiply, if desired, for producing DNA. This DNA will for the most part be identical to that of the individual of origin and will be made available for study by qualified scientists around the world. Information thus obtained will be made available for scientific purposes, including the history and origins of peoples. Knowledge of potential health importance may be acquired, for instance concerning the incidence of inherited diseases, sensitivity and resistance to infectious agents or to diet or other environmentally induced diseases, or ways to optimize vaccines for specific populations and diseases.

It should be stressed that the research involved is not new. There is already a vast amount of genetic information on human populations collected since World War I. A recent review of the available data is contained in a book entitled *The History and Geography of Human Genes*, authored by L. Cavalli-Sforza, P. Menozzi, and A. Piazza (Princeton University Press, 1994). This book contains about 500 pages of text and tables and 500 maps giving information on the geographic distribution of 110 genes in the world and by continent. The data used in the book come from over 76,000 records found in the scientific literature and published before 1987. They refer to a total of 58 genetic systems and over 300 genes, and are based on blood samples, collected in about 3,400 different locations, published by several thousand investigators.

What is new in the HGDP is the fact that genes can now be studied in greater depth, at the level of genetic material itself, DNA. This ensures a precision and completeness not possible until now. Moreover, techniques can be standardized, and DNA can be stored more easily than the biological materials used before (red or white blood cells, serum, plasma, etc.). Genetic markers are the inherited characters that can be revealed by genetic analysis. A genetic marker is defined by two or more different forms that a given gene can take in different individuals. In general, human populations differ, with respect to a genetic marker, only in the relative frequencies of the different forms. An example of a genetic marker is the ABO blood-group system, in which the gene determining the system can exist in three forms, A, B, and O. The frequencies of A, B, and O vary in different populations. There are other blood-group systems, all of which can be detected in the laboratory by immunological techniques. Other physical and chemical techniques are used to distinguish other types of makers, which have been known for decades. The investigations made by thousands of research workers with these "classical" procedures, known before the direct investigation of DNA was possible, were done in a haphazard manner, and there is considerable waste of the information then collected. For instance, population 1 might have been investigated for genes A and B; population 2 studied by a different team, for genes A and C; population 3 for C and D, limiting the number of direct comparisons among populations

for the same genes to a small fraction of all the data collected over sixty or seventy years. To reach reproducible conclusions, it is necessary to use comparisons over many different genes, and therefore much of the existing classical information cannot be employed, or at least not in an optimal manner. Nevertheless, some problems have been solved, but there remain many puzzling observations and questions, which can now be easily solved by a systematic study using modern molecular methods, at the level of DNA.

A certain amount of material has already been analyzed with modern molecular techniques, and the comparison with conclusions obtained with the classical methods shows no major discrepancies. We do not expect, therefore, any change in the basic conclusions that have already been reached with classical genetic markers, but the advantages to be obtained with a systematic collection of DNA and its analysis with standard methods are a considerable increase in the precision of the studies and an answer to the problems that escaped analysis before DNA analyses were possible.

The project will be carried out largely as an effort by each affiliated region. Supervision by the International Executive Committee and the International Forum will ensure that the scientific effort will be coordinated and that agreed-upon rules will be followed by all regional bodies. The molecular techniques employed in the project are the same as those used for molecular genetics applied to diagnostic problems in medicine or in other fields. Therefore, our insistence on carrying out the research directly in every country or region will allow these new advanced technologies to be introduced wherever biological, medical, or industrial laboratories exist. Technology transfer to the South is thus going to be a major benefit of the project.

For maximum efficiency, there should be some central storage of DNA and of the data collected. We are, however, far from having reached this point, and before this storage can be accomplished, we need to clarify minimum rules that each region must follow. A major current priority is the establishment of strong ethical rules that can be accepted generally by the many ethnic groups whose cooperation is necessary if the project is to succeed. In what follows I will summarize our current thoughts on these issues. Reactions from UNESCO's International Bioethics Committee will be very useful, especially as the project is still in its formative stages.

Basic Principles Guiding the HGDP

Minimum ethical principles must be formulated, recognizing that, in the process of collecting, the human rights of people in participating populations should be respected and that these people are partners in the work rather than merely subjects of it. Any particular region may have broader ethical concerns than those addressed here, which should be considered only as a common minimum. The principles here summarized address six points.

1. Ethical duties of regional committees

(a) Take steps to ensure that all samples are collected with meaningful informed consent, obtained from the government of the country, the local official authorities, the population sampled as a group, and also from every sampled individual. Informed consent means that all those involved have been informed about the process of taking samples, including risks, if any, and the general purposes for which the samples will be used. The language employed, and the formal embodiment of the consent, may have to vary depending on regions, situations, languages, customs, and applicable laws.

(b) Take steps to ensure that privacy of individuals participating in the project is protected. The individual identities must not be made known to the investigators handling the samples and must be respected in culturally appropriate ways.

(c) Encourage the full participation of the sampled population, as may happen, for instance, by giving the population a role in designing the questions to be studied, physical participation in the process (ideally, when possible by carrying on as much of the investigation locally, as possible, with the maximum possible participation by local scientists and personnel, and in the process promoting technology transfer), and later keeping the population informed about results. All this will be more easily feasible if, for each population, an anthropologist who is in continuous contact with that population is involved in the process.

(d) Ensure the existence of a body that reviews ethical issues concerning the collecting activity that it promotes, for example, an ethics subcommittee of the regional committee.

2. Rights of sampled populations concerning commercial use of samples or data

It is not clear if the HGD Project will lead to the development of any commercial products, but it should be ready to handle this event if it arises, under the provisos that it will not benefit financially from such projects and that some reasonable share of financial benefits shall return to the sampled population. Each regional committee, therefore, must protect the rights of the sampled populations concerning the commercial use of the samples, of data derived from the samples, and of the results of the work carried out using the samples.

A possible practical method could be based on contracts between the region and those who collect the samples under its auspices, those who use the samples or data stored in repositories, and those who use information developed from those samples or the data. The contracts could provide that no commercial use of the samples or data, or information developed from them, could be made except under conditions specified by the regional committees.

Should financial benefits develop, a share of them shall return to the sampled populations. This may happen in a variety of ways; one possibility could be that a royalty on any commercial product be paid to a third party, which could be an appropriate international organization, recognized by the United Nations or UNESCO, to be used for the benefit of the populations whose samples contributed significantly to the development of the product. Alternatively, the regional committee might require that no commercial use be made without the interested party's negotiating an agreement directly with the relevant populations. In any case, before deciding on the method to adopt, the regional committee should consult with the population concerned. The method may vary from population to population.

3. Populations to be sampled preferentially

Obviously, only populations that are interested in being sampled will participate, and those that have been more intensively studied anthropologically have some priority. On the other hand, the coordination of efforts requires that resources of the project be used economically and the main aim of the project be respected, namely, sampling populations that, taken as a whole, represent the whole world. Within these limitations, regional committees may choose samples from populations that meet one or more of the following criteria:

(a) populations that can answer specific questions concerning the processes that had the greatest impact on the genetic compostion of contemporary "ethnic groups," language groups, and cultures;

(b) populations that are anthropologically unique, exhibiting unique cultural or linguistic attributes that distinguish them from most or all others;

(c) populations that might be especially informative in identifying the genetic etiology of important diseases;

(d) populations that are in danger of losing their identity as genetic, cultural, or linguistic units;

(e) populations that are geographically, linguistically, culturally, or historically related to populations meeting one or more of the criteria above; or

(f) populations from regions, language groups, or cultural types that have not otherwise been sampled.

4. Minimum information to be obtained at each collection site

The HGD Project is not a "genetics" project but one that seeks to combine genetic information with other sources of knowledge about our species. One important consequence is that the surveys done for the Project must include not just genetic samples but also broader information about the communities that participate. Each regional committee should ensure that for each surveyed community, the following kinds of information are collected:

(a) language;

(b) general aspects of its "culture" sufficient to place it on the world culture map (e.g., residency and marriage systems, patterns of adoption or fostering);

(c) the way in which the population was sampled (e.g., by household, by lineage, at a gathering place, clinic, etc.; these data should be collected by anthropologists familiar with the group); and

for the individual:

(a) genealogical relationships among sampled individuals to the extent known within the population;

(b) birth place and place of residence of the individual and of his/her parents;

(c) if applicable, clan of individual, father, and mother;

(d) birth place,ethnic affiliation, and clan of spouse, unless both husband and wife have been sampled (in the records, localities and clan names may not be written explicitly but must be coded for necessity of privacy).

5. General availabilty of results

Each region must be committed to the general principle of sharing data and open access to all qualified researchers. Until repositories of cell lines and DNA samples, along with computerized data bases, are created and funded, however, and perhaps thereafter, absolutely free access may not be possible. Data collected by the local research workers may require that special agreements be made with the owners of those data about publication rights, if the data have not been published or accepted for publication. Other special provisions may be motivated by requests by regional committees for reimbursement of reasonable expenses in providing samples or data.

6. Technology transfer

New methods for biological research and development may prove to be the greatest technical breakthrough of the century. Knowledge of and access to those methods are spread

unevenly across the world today. Because of its global scope and the important role of local and regional scientists in the Project, the HGD Project can be a useful tool for spreading the new biotechnology knowledge and methods around the world. Each regional committee must consider how it can diffuse that knowledge, through training local scientists and technicians, through donating equipment and supplies, and through other means.

The HGD Project as an Attack on Racism

People (including scientists) who are unfamiliar with our discipline, population genetics, are frequently frightened by the idea that the study of human diversity will encourage racism. Nothing is more false; in fact, population genetics has given the best proofs we have that racism is wrong.

Racism, one of the scourges of humanity, is the belief in the inherent, biological (genetic) superiority of a race, usually one's own. Unfortunately, it is again rampant in much of the world. It is usually coupled with the erroneous conceptions that races are "pure" and that a mixture of races is deleterious. These ideas developed especially in the nineteenth century and were responsible for the most odious hatred and persecutions, even genocide, especially in the first half of the twentieth century. They are far from gone and are easily revamped when an increase in foreign immigration brings people in frequent contact with the unfamiliar faces of foreigners and their diverse customs. In the minds of most people, there is also an unjustifiable, but often complete, confusion between differences in customs, which are easily changed if necessary, and biologically inherited differences, which are not. Some of the latter are very conspicuous, like skin, hair and eye color, and facial and bodily traits. They seem to be homogeneous characteristics of populations of specific origins; in fact, they often allow us to guess with little error where a person's ancestors may have come from. I believe it is this fact which leads people to assume, even if only subconsciously, that there are only a few different, well-characterized races on Earth and, moreover, that races can be "pure" (i.e., homogeneous).

Another problem is that people are easily misled into believing that a great number of peculiar behaviors, which are simply acquired during upbringing, are also inherited like other genetics traits, skin color,etc., and are immutable. Customs vary greatly from one human ethnic group to another. Why do people frequently tend to believe that customs may be inherited genetically? I assume it is because they are automatically associated with the physical differences we observe among "races." But a great deal of our behavior is learned, and customs are patterns of behavior that are carried over generations by cultural mechanisms of transmission, which are poorly understood but have nothing to do with genetics. Many of these cultural differences are valuable and represent adaptations of great interest. Other cultural differences, however, may cause part of the resistance encountered by immigrants to foreign countries or by foreigners living in a country who are visibly different from the regular residents. It is my belief that difficulties in accepting foreigners are usually exacerbated by the very common misperception that these differences are part of the biological background and are therefore immutable.

These superficial, erroneous conclusions are thoroughly entrenched in the beliefs of many people and are in part responsible for generating hatred. To this, one may add that absurd ideas of racial superiority have often been taken as an excuse for occupying territories and whole regions previously settled by people who are less advanced economically. To these prejudices one can also add the totally unfounded, but still common, conviction that racial mixture is a cause of human racial "degeneration."

The truth is that there is no documented biological superiority of any race, however defined. Nowhere is there purity of races, except in plants and in some domestic animals that have undergone a special inbreeding process for laboratory purposes. Even in these cases there is no absolute "purity," which is very difficult to achieve. No damage is caused in humans by racial mixture. Humans thrive by remaining individually different one from the other. In fact, the concept of race can hardly be given a scientific, careful defintion.

Why, then, do we see conspicuous differences among people originating from, say, Africa, Europe, or East Asia or among Native Americans or Australians? The explanation is that these differences are the result of physical adaptations to different climates, adaptations that developed only very recently in the history of humans, following their spread to continents, most probably starting from Africa between 60,000 and 100,000 years ago. Moving from hot climates to temperate or cold and extremely cold ones, or changing diets because the flora and fauna were different, has mediated such adaptations. It is likely that these differences are superficial, because the surface of the body is the place at which the interior of the body and the external environment (and the climate with it) come in contact. It is very easy to understand that adaptation to strong ultraviolet radiation from the sun has favored a development of protective pigmentation, hence dark skin. On the other hand, white skin helps in producing vitamin D. Not enough of this vitamin is present in the cereal diet to which Europeans have adapted in the last ten thousand years. Were the skin dark, not enough solar ultraviolet would penetrate it to allow the production of vitamin D from precursors present in cereals. Rickets would develop. Thus, at high latitudes, where the solar radiation is weak (unless the diet includes much fish and meat), the skin must evolve toward a lighter color. All other traits convince us, upon closer observation, that the superficial differences among "races," such as the shape of the face, of the eyes, of the nose, and the size and shape of the body, have most likely been engineered by nature so as to provide better adaptation to the different climates.

Thus, the characteristics we see with the naked eye that help us to distinguish individuals of the different continents are, in reality, "skin deep," and whenever we look under the veneer we find that the differences that seem so conspicuous to us are really trivial. The study of human population genetics has produced a most important result: apart from these superficial differences, which are few, individual humans are genetically quite diverse, but the average differences among human groups are small. They are much smaller than the superficial, skin-deep differences would lead us to believe, and they are also relatively small compared with the differences existing among individuals within the groups. When I say "groups," I am trying to replace the more common word "race," which is misleading because it is impossible to define accurately (and it is full of unpleasantness). A better word is "population," however defined: that of a village, a town, a region, or even a continent. Even a remote village is highly heterogeneous genetically when you look at truly inherited characteristics under the skin. Just to give some idea, a remote, highly isolated village may have a heterogeneity among individuals that is 50% or 60% as great as that of the whole world. Nevertheless, by a sufficiently detailed study we can find differences and similarities everywhere. Villages that are geographically close also tend to be similar genetically, but we can show that they differ, although very slightly, provided that we examine enough genes and individuals. Genetic analysis can be used to define close relatives or even individuals, given knowledge of their relatives. This is because genetic differences among *individuals* are of great magnitude. On the other hand, there has not been enough time to build up great differences among human *groups*. The greater the time since the divergence among groups began, the greater genetic diversity is expected. But humans started diverging only recently . Biological evolution is very slow, and there has been insufficient time to generate great differences among human regional groups. Those we see superficially are very noticeable, but the other characters that we see only by laboratory techniques are the greatest part of the differences among us, and these show

small differences among groups. There has been no special reason for them to increase as dramatically as differences in skin or eye or hair color and the other superficial adaptations to different climates. The latter must of necessity affect the surface of the body and are, of necessity, very conspicuous. We should not be misled by this association into thinking that the hidden genetic differences are also as great.

Conclusion

Science per se, done in the interest of intellectual curiosity and in respect of life of humans and other species, is morally clean. Its applications must be, however, under the control of society, because they can be good or bad. It is mostly because of such applications — or because of disagreement with religious dogmas — that science has come under fire, often for the wrong reasons. Ignorance can breed fear and hate, but I have discovered that it is most dangerous when mixed with the personal political agenda of science haters. We must take care to communicate about our project to a wide variety of audiences, many of which do not understand scientific methodology.

I am not suprised when I am attacked by racists because of my ideas; it is perfectly understandable. We cannot share any common ground. The confusion made by some others between our study and eugenics is less easy to understand or to forgive. The data and theory of population genetics show how difficult, or impossible, it is to carry out a eugenics program. It has even been asserted that the knowledge we generate can be used for the genocide of indigenous people. The vast genetic differences among individuals and the small differences between populations make any such application impossible. These kinds of baseless allegations stem largely from a general lack of understanding of human genetics. The Project will make strong efforts to combat this.

The information on genetic variation among individuals collected in the last sixty or more years, when there was no plan to coordinate the project, has already generated important knowledge. The new technologies applied according to the plan that we envisage will allow enormous improvement in our current understanding. Not only will intellectual curiosity be better satisfied, but also useful medical applications will improve welfare, and knowledge developed in this way will help further to reduce the impact of racism. The project is also an easy way to introduce important new methodologies to enable technology transfer to countries of the South. If any financial benefits come from pharmaceutical applications of the knowledge thus acquired, the HGD Project is also one organization that recognizes the rights of the original donors of biological material to participate in the benefits.

The Educational, Scientific, and Cultural importance of this project, as in the third, fourth, and fifth letters of the acronym of UNESCO, should be clear. We hope that we can establish useful links with UNESCO's International Bioethics Committee to further the Project's important work. I take from a section of the Alghero report, which is included in its entirety as an Appendix, the following sentences, which are a good summary of the Project:

> The primary case, therefore, for the Human Genome Diversity Project is cultural. The study of genetic polymorphism in human populations creates a unique bridge between the science of human genetics and the humanities, including anthropology, archaeology, history and linguistics, and present scientists with a unique opportunity to contribute to the world's cultural heritage. There is a cultural imperative for us to respond to that opportunity and use the extraordinary scientific power that has been created through the development of DNA technology to generate — for the benefit of all people — information about the history and evolution of our own species.