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Technologies of similarities and differences : on the interdependence of nature and technology in the Human Genome Diversity Project

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Chapter 1

By Way of Introduction

The Researcher in the Field:

On the 15th of December 1996 I went to Munich Airport to pick up a well-known professor in population genetics. She had travelled from Tel Aviv to visit the laboratory where I was conducting my research. After we had tracked each other down in the crowd we took the train back into the city. Professor B-T turned out to be a very pleasant person and quite soon we found ourselves in animated conversation. She told me about the rare DNA samples that she had brought along and where she had collected them. The Lab was looking forward to the samples, specifically because it was running short of male samples from these populations. She had heard that I too was going to use the samples for my research project. I told her about my study and what I had uncovered thus far. At the same time I started to feel a bit uncomfortable. I felt the urge to “reveal” my “identity” to her. Because I was not just a member of the lab: I was also studying the Lab. But before I could do so, professor B-T was eager to learn where I came from. I told her that I lived in Amsterdam but that I am originally from Tunisia. A bit shy but curious, she asked me whether I was also from “one of those interesting populations.” I had to disappoint her there, but I told her about the genealogical history of my family, which dates back over a couple of hundred years and goes back into Lebanon.

Two years later I was visiting professor B-T in Tel Aviv. She invited me to her laboratory and introduced me to her group. I learned that her lab housed one of the consortia of the Human Genome Diversity Project, where they were growing cell lines of various population samples. Also when she introduced me to her colleagues I was surprised that I was not introduced as a social scientist but as a member of the Laboratory in Munich.

The Stakes and the Argument:

In 1991 a group of population geneticists embarked on an international project designed to map human genetic diversity. The initiators of this Human Genome Diversity Project were interested not only in mapping

contemporary genetic diversity as such but also in studying how the current diversity had evolved and how genes had spread over the world. Knowledge of the origins of populations, as one of the initiators of the Project has stated, would have “enormous potential for illuminating our understanding of human history and identity.”¹ By tracing similarities and differences in the DNA of various groups of people, geneticists aim at reconstructing where humans come from, how they migrated and how different groups of people relate to one another. To do so a special emphasis is placed on the study of “indigenous peoples” and “isolated populations.” They are deemed the “treasure keepers” of original information which, in the course of history, had gradually been obscured in other large groups because of migration and admixture. Isolated populations are held to be conservative in this respect by geneticists.² As distinct populations their DNA is considered to be representative of all human genetic diversity and therefore convenient for attaining the goals of the Human Genome Diversity Project (hereafter, the Diversity Project).

The Diversity Project was launched with a rhetoric of preservation, time pressure, and alarm. In June 1991 the journal *Science* published an article headed: “A Genetic Survey of Vanishing Peoples,” which opened: “Racing the clock, two leaders in genetics and evolution are calling for an urgent effort to collect DNA from rapidly disappearing populations.”³ One of them, the population geneticist Luca Cavalli-Sforza argued that “if sampling is too long delayed, some human groups may disappear as discrete populations [...]. At a time when we are increasingly concerned with preserving information about diversity of the many species with which we share the Earth, surely we cannot ignore the diversity of our own species.”⁴

However the Diversity Project soon ran into trouble. It was faced with a variety of criticisms, especially from indigenous and environmental organisations. It was soon dubbed “The Vampire Project,” referring to the collecting of blood samples.⁵ Furthermore this naming suggested that the groups from which the samples were taken were ill-informed and misled by geneticists and that the samples were collected for interests other than those of the sampled groups. In the television documentary *The Gene Hunters*, the professor of medical ethics George Annas (MIT) put it as follow: “We’re taking from them their DNA, which we now consider like gold. It’s even worse than standard colonialism and exploitation, because we are taking the one thing that *we* value, and after we take that, we have no real interest in whether they live or die.” In that same documentary the spokesperson for the Arhuaco People, Leonora Zalabata, stated: “Our land, our culture, our subsoil, our ideology, and our traditions have all been exploited. This [the Diversity Project] could be another form of exploitation. Only this time, they are using *us* as raw material.”⁶ The criticism led to a debate about the social

and ethical aspects of the Project. In 1993 the Rural Advancement Foundation International (RAFI) as well as other political agents urged geneticists to incorporate indigenous organisations in every step of the Project and to reassess its scientific and ethical implications. And by the mid-1990s many other organisations, including the *Bioethics Committee* of UNESCO, were calling for strict regulations of how to sample and handle the information obtained. The project had also become part of a debate about commercial revenues in science, such as the patenting of human genes and the development of drugs for specific diseases. Geneticists, however, have emphasised that their initiative had no commercial interests, nor will they accept funding from commercial agents.⁷ They argued that the knowledge resulting from the Project may contribute to the understanding of genetically inherited diseases but its major goal is an investigation of genetic diversity and the history of human migration. This “pure science” approach has also been looked at with suspicion, for example by Ray Apodaca, a spokesman of the “National Congress of American Indians”. Countering the “pure science” claims he stated: “We know where we came from, and we know who we are, and we think we know where we are going. Why do we need to know anything else? I mean, is this for their benefit? It certainly isn’t for ours.”⁸

In the face of this criticism the Diversity Project has met initial problems finding financial or other support within the scientific community and institutions.⁹ Yet in Europe the Human Genome Organisation (HUGO) proved at an early stage to be willing to finance a series of workshops in order to assess the project’s scientific values, whereas in the US the project was put on hold for several years. Only by the end of 1997 had a committee of the US National Research Council (NRC) evaluated the project and found that it should receive financial support within American national borders, provided that it met ethical and legal restrictions placed on genetic research funded by federal agents.¹⁰ While few research projects receive financial support, some Diversity Consortia for the storage of samples and the growing of cell lines have been established, such as the one we encountered in Tel Aviv. Thus, although haltingly, the Diversity Project has started.

This book is about the Diversity Project. More specifically it deals with genetic diversity in scientific practice. Prompted by the issue of “conserved genes” and the mapping of similarities and differences between populations, it focuses on what genetic diversity is made to be in scientific practice. The brief review of the controversy shows some of the political stakes in the Diversity Project. Rather than a study of that controversy and of the different politics involved in the debate outlined above – however important and interesting in its own right – this book aims at tracing the politics of genetic diversity in laboratory routines. Thus it investigates the daily practice in which humans, samples and technology are aligned to

produce the stuff of which the power and prestige of science is made. The argument carried on throughout this book is that genetic diversity is not an object that lies waiting for the scientist to discover, nor that it can be treated as a construct of scientists. Genetic diversity involves a complex scientific practice. It is not only dependent on the scientist and the DNA but on various technologies applied to produce it.

Let me briefly illustrate the relevance of technologies for the Diversity Project. For instance, the haste with which geneticists aimed at “conserving” human diversity before “isolated populations” ceased to exist as such cannot be explained exclusively in *social* terms. What is at stake is not so much the fact that the lives of these groups of people are endangered or that their integrity is threatened because they nowadays tend to migrate and mix more frequently with other groups than in previous times; nor is it that these groups only drew the attention of geneticists in the late 1980s. Many of the geneticists participating in the Diversity Project had already been studying and comparing these populations previously and had even stopped doing so in the 1970s because they “ran out of data.”¹¹ With the technology available these scientists could acquire no more information from the samples they had. What *did* change by the end of the 1980s was the availability of new technologies. The introduction of revolutionary technologies to the field of genetics had made it not only possible to produce new “data” based on the samples already collected but also brought within reach a study of diversity on a much larger scale. What these technologies are and how they affect what genetic diversity is made to be, is therefore at the centre of this book. Consequently rather than whether or *not in our genes*,¹² the question addressed is *how in whose genes?* Before going into the details and the organisation of this book, let us first go back to the Diversity Project to have a second look at how it is organised.

The Diversity Project:

The Diversity Project did not emerge in isolation. Many more genome projects were launched in the 1990s and before. Most powerful and well under way is the *Human Genome Project*. Since the Diversity Project was presented by its initiators as a response to the Human Genome Project (HGP), let me elaborate on the latter. The aim of the HGP is to map and sequence the complete human genome.¹³ The sequence map will function as a reference genome by which all human individuals can be located and compared. As *the* reference, it will provide the genetic terms in which all individuals will be expressed.¹⁴ One of the initiators, the geneticist Walter Gilbert, presented the HGP as the ultimate means to know oneself. He insisted most strongly that molecular biologists would have the final answer

to what it is that makes us human, namely the DNA. One of his most quoted statements is that: "one will be able to pull a CD out of one's pocket and say, 'Here is a human being; it's me!'"¹⁵

The CD metaphor is obviously a pregnant one, not only because it allows Gilbert to make his argument tangible during his presentations by actually pulling a CD out of his pocket but also because it underlines the technical aspects of genomes and genetics. However, riding on that metaphor, the political stakes are not only in knowing what the CD is, but also how and where the CD is produced. What kinds of polymerised substance, stencil-plate and printing technologies contribute to the CD? How can it be played and what kind of equipment is necessary? How can it be read and who will be able to read it? Who will have a CD? What about the possibility of copying it? And will the result be a copy or a clone? But, also, what kind of place will the CD-of-life take in the collections of those who have many different CDs? Will it be able to compete with a CD containing a family photo album, with one bearing a game called *Doom* or with that of a singer called *Fairouz*, and what kind of practices make the one CD more important than the other? And since the goal of the HGP is to produce *one* CD, a question raised within the confines of genetics as well as outside is, whose CD is it going to be?

The first complete human sequence was expected to be that of a composite person: it would have both an X and a Y sex chromosome, which will formally make it a male, but this "he" would comprise autosomes [non-sex chromosomes] taken from men and women of several nations – the United States, the European countries, and Japan. He would be a multinational and multiracial melange, a kind of Adam II, his encoded essence revealed for the twenty-first century and beyond.¹⁶

Thus states Daniel Kevles, half ironically, in *The Code of Codes*, an interdisciplinary book about the HGP. However some geneticists outside the realm of the HGP claimed that "[t]he Human Genome Project aims to sequence "the" human genome with DNA taken mainly from individuals likely to be of European ancestry in North America and Europe. But, like all brothers and sisters, all humans have slightly different genomes."¹⁷ They therefore suggested another genome project, the Human Genome Diversity Project, which "wants to explore the full range of genome diversity within the human family."¹⁸

Studies of human genetic diversity among are not new and go back to the beginning of the twentieth century, when they were based on blood groups. In addition DNA-based genetic research has had its heyday from the mid-1970s onwards.¹⁹ Hence the initiative of the Diversity Project takes up from ongoing research. Yet every project has a myth of origin.²⁰ There is a date of birth and there are great men involved; there is a vision and there are

allies inside and outside the field; there is a world to be gained and ghosts to be exorcised. What follows is the origin myth of the Diversity Project.

The Diversity Project was initiated in 1991 by the late Allan Wilson (professor of biochemistry at Berkeley) and Luigi Luca Cavalli-Sforza (professor of population genetics at Stanford). Together they found more colleagues welcoming their plan to map genetic diversity among human populations on a worldwide basis.²¹ The values of this initiative (referred to in the quote as the HGD Project) were summarised as follows:

- The main value of the HGD Project lies in its enormous potential for illuminating our understanding of human history and identity
- The resource created by the HGD Project will also provide valuable information on the role played by genetic factors in predisposition or resistance to disease
- The HGD Project will bring together people from many countries and disciplines. The work of geneticists will be linked in an unprecedented way with that of anthropologists, archaeologists, biologists, linguists and historians, creating a unique bridge between science and the humanities
- By leading to a greater understanding of the nature of differences between individuals and between human populations, the HGD Project will help to combat the widespread popular fear and ignorance of human genetics and will make a significant contribution to the elimination of racism.²²

A central question of population genetics is: how did humans migrate out of Africa to colonise other regions in the world and when did these events take place?²³ The idea is that human genetic makeup is indicative of historical events and vice-versa, that the contingency of human history is reflected in the DNA. By tracing similarities and differences in the DNA fragments of various populations, geneticists aim to provide another account of human history. Culture and nature are thus levelled in the Diversity Project.

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.²⁴

To reach this goal the initiators aimed at an internationally organised project, a project based on technologies and knowledge developed within the realm of the Human Genome Project (HGP) and capable of redirecting the work conducted in the field of population genetics. As early as 1991 the Diversity Project was “adopted” by HUGO, the Human Genome Organisation, established in 1989 within the HGP. To assess the potentials of the project in Europe, HUGO set up an *ad hoc* committee in the autumn of 1991. This committee was charged with organising a series of workshops

where various aspects of the project were to be discussed and evaluated, such as the methods of sampling and the storage of the samples, the technologies to be applied and the processing of the information, as well as the social and ethical aspects of the project. The committee was also asked to conduct a pilot study, using already existing samples, to show the relevance of the project and to adjust the protocols for the forthcoming research.²⁵ In the first five years the project as a whole was estimated to cost 25-30 million American dollars. HUGO provided 1.2 million to organise the workshops and to conduct a pilot study. Additionally HUGO helped create a more friendly political climate for the project to get started. The Diversity Project is now organised in a number of regional committees responsible for their own initiatives.²⁶ Whereas the European regional committee was receiving EEC support as early as 1992, the North American regional committee had to wait until 1997 for federal support and funding.²⁷

Making a Genetic Map of the World:

How to make a map of the world, one that shows genetic relief and contours, is obviously the major goal of the Diversity Project. Aimed at reconstructing human-migration out of Africa and the spread of humans and their genes around the world, the effort is to assign different *populations* to different loci on that map. Yet its two initiators, Cavalli-Sforza and Wilson, already had conflicting ideas about the sampling strategy, i.e. about what a *population* is. Whereas Cavalli-Sforza had strong ideas about how to define a population, namely on the basis of linguistic criteria, Wilson argued against any presupposition about what it is. In an interview with *Science* Wilson stated: "We should abandon previous concepts of what populations are and go by geography. We need to be explorers, finding out what is there, rather than presuming we know what a population is." Hence his idea was that what population *is* should be the outcome of genetic research and not the start. He therefore suggested a grid sampling based on geographical distances (100 miles).²⁸ The grid approach, however, was considered too costly in terms of time and money, and categorisation according to linguistic criteria was regarded to be the most appropriate.²⁹

Using linguistic criteria, geneticists were faced with 5,000 different populations.³⁰ But, as in the case of a geographical grid, sampling, storing and studying all their cell material did not seem feasible either. Geneticists have therefore decided to focus on a number of 500 populations. The criterion for the selection of populations was that they should be representative of overall human diversity. Additionally priority should be given to obtaining samples from "isolated populations," "anthropologically unique populations," "populations that can give clues about genetic diseases

or about contemporary ethnic, language or cultural groups,” and “populations in danger of losing their identity as genetic units.”³¹ These qualities do not only give clues about what it means to be genetically representative. They also suggest that the linguistic criterion is highly invested with various social, cultural and biological qualities and features.

In an article published in the *Scientific American*, Cavalli-Sforza reports on the correspondence between the distribution of genes and that of languages among populations. Elaborating on the transmission of genes, language and culture from one generation to the other, he distinguishes between a vertical and a horizontal transmission, the first being a transmission between parents and offspring, and the latter a transmission between unrelated individuals. Whereas genes can only be transmitted vertically, culture and language may be passed on either way. While identifying the difference between “isolated populations” and populations that have undergone admixture, he states:

In the modern world horizontal transmission is becoming increasingly important. But traditional societies are so called precisely because they retain their cultures – and usually their languages – from one generation to the next. Their predominantly vertical transmission of culture most probably makes them more conservative.³²

Hence language is not just an arbitrary means of distinguishing between groups of people: it is deemed to correlate with the genes. More specifically this correlation is held to be even more elegant when applied to the Diversity Project’s object of study, namely “isolated populations.” Analysing and comparing the similarities and differences found in various of these populations, geneticists aim at gaining insight into “genetically complex” populations, i.e. populations that are less isolated, less unique and less easy to categorise and to study. It seems that those who are not considered to be connected to the global traffic of humans and things, especially those in far-off places, are considered best sources for understanding how genetic “melting pots” must have come about.³³ Based on the idea that all genetic diversity is better preserved in “isolated populations” and the idea that all humans belong to one “genealogical family” originating from Africa, these populations are assigned the role of origin and resource.³⁴ They are thus considered to be more homogeneous and their genetic makeup to be more conserved. But how can they then represent an overall human diversity, such as aimed at by the Diversity Project? In addition to their homogeneity and conserved genes, the genetic makeup of different “isolates” in different parts of the world is held to represent specific moments in the history of human migration. These migration events may also be represented in intermixed groups but their effect on the clustering of genes tends to be blurred due to population admixture. This indicates that representing human

genetic diversity at large can only be done if different “isolated populations” from different parts of the world are taken into account.

The emphasis placed on “isolated populations” is relevant for studies of diversity not only in the context of human history but also in that of genetic diseases. In a document issued by the Diversity Project this relevance is phrased as follows: “Every time we ask whether a particular genetic marker is associated with a disease, we need to know about the normal control population. The need for this comparison increases with the diversity of the population.”³⁵ Thus in order to understand the mechanisms of inherited diseases in genetically diverse populations, “isolated populations” may function as normal control populations. With the help of such information geneticists aim at tracing where specific genes or genetic mutations have come from, and whether they lead to the same effects - that is, also cause diseases in the control population. However in cases where the specific genes related to a disorder are not known, the role of an “isolated population” might be different. For example, if such a population is susceptible to a specific disease, studying that particular population and not one where genetic diversity is greater may be understood in terms of the reductionist method of the natural sciences.³⁶ Applied to an object of research, this method consists in reducing complexity to a small number of controlled variables that *can* be studied in a laboratory context. In line with this, “isolated populations” rather than normal control groups function as resource material.³⁷ As a geneticist once explained to me: “It would be crude to place a wall around Friesland [a province in the Netherlands], and observe what happens to its “isolated” inhabitants. These populations live isolated by nature and can give us insight into the development of various diseases.” Although geneticists would consider these populations interesting for studies in their own right, within the context of the Diversity Project they occupy the position of reservoir and could be seen as a “natural” laboratory for the rest. Whether the aim is to reconstruct the migration history of humans, to preserve human genetic diversity or to study human genetic diseases, the Project makes some populations into a more appropriate resource than others.

Studying genetic diversity within the context of a project does not only affect what may be considered a population, what a population is and how it is deemed to contribute to its research but it also affects genetics as a field. Within the Diversity Project geneticists had to decide upon how to sample, how to store the samples and what kinds of technology will be used to study the samples. To create a project they simply have to work together and standardisation is an important condition for achieving that.

The Diversity Project aims at collecting 10,000 – 100,000 samples from the 500 populations under study. The sampling is delegated to the

regional committees who should, where possible, work together with “local” scientists and anthropologists in the field.³⁸ When the samples leave these regions they should not travel alone: they should be accompanied by information about the region and about the sampled individual. Information regarding “sex, age (or approximate year of birth), current residence, place of birth, linguistic affiliation [of these individuals and] current residence, place of birth, cultural affiliation, linguistic affiliation [of the individual’s] biological parents,”³⁹ should accompany the samples to central places of storage. Thus the study of the diversity of these populations involves more than cell material or DNA.

From most individuals only a small quantity of cell material will be collected – blood, hair root, or inner cheek tissue. The samples will be stored as DNA in DNA libraries. Thanks to copying technologies even small quantities of DNA are sufficient for study purposes. But since samples will also be used to produce cell lines, more cell material is needed from 10% of the sampled individuals. Their white blood cells will provide the Diversity Project with a permanent source of DNA.⁴⁰

In the Diversity Project it was emphasised that the proposed research is not new. It is stated that:

[w]hat is new is the possibility of extending the study of population to a much more detailed level by applying some of the DNA technology (such as the PCR-based technology mentioned above) that has been developed within the last few years in the context of the Human Genome Project.⁴¹

Yet to study DNA and thus to know a population, geneticists have different tools at their disposal. Studying a population in terms of height, for instance by measuring from head to toe, does not make that population comparable to another studied in terms of weight, measured in kilograms. Hence one of the major efforts of the Diversity Project in this respect is to co-ordinate and fine tune the technologies that should be applied for all populations equally: the kind of DNA copying technologies, such as PCR, the specific fragments of variable DNA to be studied, also called markers, and the kind of statistical means of comparing the data.⁴²

As is the case for the HGP, technology is also at the centre of the Diversity Project.⁴³ It accounts for the project’s potential for population studies. It is argued that “[a]s a result [of revolutionary technology], the precision with which populations, their origins and their interrelations can be defined, using relatively small samples, has increased enormously.”⁴⁴ Still, whereas the technology is cutting edge and allows for genetic studies even on the basis of small samples, geneticists find themselves confronted with a problem. “[T]he human species is moving towards increasingly intensive amalgamation” and populations are losing their identities in terms of genetic similarities and differences.⁴⁵ This is considered to be the “irony” of the

Diversity Project. An irony that makes it turn to isolated and aboriginal populations instead.

In the course of the Diversity Project there emerged yet another irony, which had to do with the project's object of research. The international project organised to sample and study "isolated populations" created opposition to itself on an international level and met with harsh criticism from the very populations under study.⁴⁶ As already mentioned, Tribal Governments and other organisations of peoples around the world started to make trouble for the project.⁴⁷ Although some populations have decided to collaborate in order to learn more about certain diseases that prevail among them, or to benefit from the promised technology transfer, many more have organised themselves on an international basis against the appropriation of their body tissue. As well as being dubbed the "Vampire Project," the Diversity Project was also categorised as "bad science," a post-war category for racist science.⁴⁸ The joint interest in genes and populations was considered to reify biological races, and to essentialise differences.

Making a Book:

As can be seen, the Diversity Project is complex, broad and controversial. This increases the many different ways in which it could be studied.⁴⁹ What comes to the fore is its controversial character, its blunt "science for the West and genes from the rest" kind of appearance. While this is disturbingly important, I chose a different angle. Instead of contrasting "genes" to "science," in a kind of naturalised dichotomy between nature and knowledge, and instead of a geographical separation between the *worlds* of the populations studied and the *words* of the scientist studying them, my aim was to investigate how they are made into constituent parts of genetic diversity. Where to do my study was a matter of "choice". As I explained at the beginning of this chapter, I did not choose to study the public debate around the Diversity Project, but nor did I choose to study the populations aimed at by this project. Going out to study them seemed to me invasive, specifically since until this study I did not have any specific affiliation with indigenous people or their organisation, something that I did have with the sciences. In addition, even though it was easy to side with the criticism against the Diversity Project, it seemed to me that the debate was too neatly organised along the lines of wrong and right or good and bad. This increased my curiosity about the Diversity Project and raised the questions: what is it about, and how does it or will it change our world? I contend that genetic diversity cannot simply be the end-product of knowledge applied to populations or their DNA:⁵⁰ I had grown interested in what it involves in scientific practice.

As is shown in the brief introduction to the Diversity Project above, the study of diversity requires a certain standardisation of practices. Hence the emphasis is placed on fine-tuning the Project's "materials and methods." As pointed out, standardisation had to be arrived at in the case of "population", how to define populations and how to sample them, and in the case of technologies such as the DNA copying technology, the fragments of DNA to be studied, as well as the statistical models to be applied.⁵¹ Rendering genetic diversity and data about populations comparable between laboratories, therefore, enhances a routinisation of scientific conduct. It is this very routinised and "nothing strange going on here" kind of practice that I examine in this book. Genetic diversity will be traced in such practices where various technologies are employed routinely to produce it.

Because it focuses on laboratory routines this book can be placed within a specific tradition in science and technology studies (STS). Since the late 1970s a number of studies have been published based on detailed ethnographies of laboratory work and daily routines.⁵² These studies, the so-called *laboratory studies*, have in many ways redefined the field of STS and have suggested new methods of studying the sciences. In line with Thomas Kuhn's observations on and questioning of the cumulative nature of science, they have countered the idea that science is guided by rationality only.⁵³ They have suggested that science could best be understood as a heterogeneous process in which humans and non-humans (technology, theories, chemicals) are "alignments" to get the job done. In addition, in these studies the scientific object as such also went out of focus. Instead, laboratory ethnographers suggested that to understand scientific facts one should focus on what scientists actually *do* and the various technologies they apply in making science. For example, in their laboratory ethnography Bruno Latour and Steve Woolgar focus on how scientific facts are made, and show how in that process references to where and how these facts were produced are gradually removed and detached from that end-product.⁵⁴ Thus instead of end-products, as accounted for by scientists in – for example – published papers, the topic was changed into the *material culture* in laboratories, and how science is done in *practice*.⁵⁵

Although this book developed to occupy a place in STS, it originally came to life in an institute for gender and multi-cultural studies.⁵⁶ Studying gender or racial aspects of science, feminist and anti-racist scholars have examined and traced biases in the language or discourse of science, giving insight into hierarchies in the designation of agency to naturalised categories.⁵⁷ This may be a hierarchy between the races, the sexes or between racialised or sexualised entities that do not necessarily coincide with human individuals, such as the wild type versus the mutant/specimen, the active sperm versus the passive egg cell.⁵⁸ Others have traced biases in the social

groups that do scientific work, showing a male bias and revealing the contribution of women and occasionally that of men and women of colour.⁵⁹ Again others have considered scientific methods and argued that these could be categorised as Eurocentric and masculine. Methods were shown to set a distinction and a hierarchy between a (masculine) *subject* of research, namely the scientist, and a (feminine) *object* of research, namely nature. But also between culture as an achievement of Western science and nature as the naturalised and pre-given non-West.⁶⁰

In line with some of the concerns of feminist and anti-racist scholars this book is aimed at discussing normative aspects of genetics. It investigates genetic diversity and pays special attention to how genetic sex and race are produced in genetic research. It does not intend to study what geneticists think, nor how they talk about sex-difference or race. The aim is not to unmask geneticists as being racist, sexist or biased in any other sense. For the point is not so much *who* is conducting genetic studies as *how* is it done. I therefore want to examine how race and sex-difference are locally "achieved" and the auxiliary work of technologies in producing them.

This book does not stand alone in addressing normative issues combined with an interest in scientific practice. A relatively new branch of STS also deals with the subject.⁶¹ It has produced studies that pick up and re-address classical normative questions, such as: how does science and technology change social worlds and for whose benefit? How do social worlds get built into technologies? What kind of politics do technical objects carry with them? And how do they affect the ordering of the world and processes of inclusion and exclusion?⁶² Especially in studies of medical practices and the new-reproductive technologies, scholars have paid attention both to how scientific facts are assembled, made and consolidated, and to the morality borne by technologies. They have raised questions concerning normalisation, naturalisation and standardisation, and have investigated how personhood, gender or the body are locally achieved.⁶³ My studies benefit from insights developed in this and other branches of STS, as well as gender and anti-racist studies, and want to contribute to these fields. While laboratory studies have contributed to the understanding of scientific practice and scientific routine, little attention has been paid to the object of scientific research as such. Conversely in gender and anti-racist studies little attention is paid to scientific practice, specifically not to the practices of laboratories.⁶⁴ Studying the sciences, gender and anti-racist scholars have shown particular interest in the effect of knowledge for the object of research, and not infrequently this object was the female or coloured body. This book is a study of how objects are made in scientific practice and analyses the politics involved. Additionally there is a tendency to treat the politics of science as deviancies,⁶⁵ specifically when the issue is racism or sexism. Studying

genetic diversity in laboratory practice, this book examines how such politics get built into standardised technologies and laboratory routines.

There are several reasons why I studied the Diversity Project in the laboratory. First of all because I was inspired by the work of other scholars who have conducted laboratory studies: this tied in with my general interest in the sciences. Secondly, because of a kind of morality that says that “you have no right to speak unless you know what you are talking about.” And I did not know much about genetics. Ironically enough, I learned in the laboratory that there are many ways of knowing and thus many rights and reasons to speak. The third and major reason had to do with the Diversity Project itself. Although I was both alarmed and troubled by the initiative, I was hesitant to subsume the project in a general critique of “imperialism” and racism in science. Besides, why would this project be “bad science” whereas others were not?⁶⁶ I wanted to make my criticism specific, so I decided to get closer and see how genetic diversity was done. The *Forensic Laboratory for DNA Research* in Leiden offered me training in some of the basic tasks of a technician. I was there for three and a half months and combined the training with a study of the laboratory itself. Together with the head of the Laboratory I attended a conference on the Diversity Project, where I met many of the scientists participating in the project.⁶⁷ At this conference I met the head of the *Laboratory for Human Genetics and Evolution* in Munich. In 1997 I spent six months in this second laboratory and participated in one of the projects in the field of population genetics. The analyses presented here are based on participant observations in both these laboratories.

I wrote down my observations either in the laboratory itself or in the evenings at home and conducted interviews with members of both labs at the end of each study. In gathering published papers I was struck by the generosity and involvement of lab members in bringing some of them to my attention and for keeping me up to date, even after I left the laboratories. Having been engaged in laboratory work made it easy to become “a member.” But it also imposed some constraints upon my fieldwork. First of all, the temptation is to go epistemically native. A major reason for this is that a laboratory environment imposes a specific type of normalisation upon those who work there. The very fabric of the lab demands a kind of subjectivity centred around the pace of the work, the planning of experiments, the talks that are often about problem-solving such as machines that are overbooked or not working, or about how to get the data and when to write down the results. Once I became familiar with the various projects it proved difficult to relate to them other than within the conditions of these practical concerns. In addition, several times during my research

participation stood in the way of observation. Often there was simply no time to take proper notes or to be where the action was.⁶⁸ My main focus at such times was to get the results, to make things work, or to establish the conditions for the experiments.

Yet as an observer one is also tempted to neglect these practicalities of research and to develop a kind of science critique instead. In a sense, it is tempting to tell the strange stories back home without bringing along "the lab". However, my experience was that lab members were themselves aware of the social aspects of genetics, especially of racial issues. They were self-reflexive upon their work and the particular environment in which they carry it out and were capable of taking a distance in order to develop a more sceptical view.⁶⁹ In a significant sense this helped me to centre my analyses around technologies and local practices and not to impose predetermined categories on the kind of work they do. Another and related point is that in some ways one can never really leave the lab. My experience is that both positions of participant and observer remain intact. This became apparent during the many visits I paid to the laboratories after I had finished my field work, in the various personal contacts that I maintain with some of the lab members and in the material objects that I brought home, such as my (observer) field notes and my (participant) lab journals. Hence participation and observation continued in parallel during the process of writing and had to be negotiated in various drafts of the chapters. While the ties which I developed with the laboratories may be particular to my studies, the point itself is, however, more general and methodological. I will therefore expand on it.

There is a certain epistemic quality to the phenomenon of participant observation. It disturbs research design, time schedules and methods set out for gathering the material; something probably common to all research. But it does more. Participant observation requires the researcher to go out to study the other culture, yet it disturbs the very distinction between the field, there, and the writing, here.⁷⁰ This blurring of boundaries in the end-products of participant observation, i.e. in written texts, has been brought to our attention by ethnographers such as Clifford Geertz.⁷¹ However I wish to point to another aspect of participant observation and explain the epistemic quality mentioned above. After I had finished my fieldwork and went home to do the writing I was confronted with the field once more. It was right there, on my desk. Not only had there been DNA samples in my refrigerator, "gel Polaroids" in files, but also the field notes, documents and papers appeared to be much more than artefacts from another world. Once some of the material had found its way into one of my chapters it started to do its own work. At some points it refused theorising, it refused even to get out of my texts again. And so now and then it urged me to go back out *there* and learn

more about it, in the library, in MedLine or in the laboratory. It occurred to me that the complexity of the locales I left behind had travelled all along, not only with me, because I had been there, but especially with the material. Thus it is not only in the final texts of ethnographers that the boundary between the field and the writing is blurred, but also *during* the writing, due to the very capacity of the field to move to other places in the world via such ethnographic material. It is in this sense that my statement, that one can never really leave the lab/field, should be understood. It might also be for this reason that ethnographers have grown to be squeamish about their material since it always bears with itself a world that wants to speak, often with many voices.

Does this mean, then, that the material presents itself or the world it comes from? Does this mean that writing is without theory?⁷² Even though “the field” was on my desk, it was not there by itself. There were also theories in the form of texts. Books and articles from the field of STS, gender and anti-racist studies, but also philosophy, anthropology, cultural studies and genetics. They dealt with bodies, gender, technologies, gifts, cultures, race, hormones, double helixes, genomes and blood – among other things. Both material and theory had to be negotiated in the process of writing. And the final text of this book is an analysis and not a description of what the field is like or how it can be found out there. At this point let me be explicit about the chapters. The narrative of each chapter evokes a distinction between ethnographic accounts and their analysis. This might be read as a distinction between the reality of the field and reality of writing, i.e. the analysing and theorising of the material. Even though the ethnographic accounts are faithful to the material I gathered, these too are assembled, framed and guided by theory. They are thoroughly theorised. As I have stated, the material had to negotiate its place in the final text. In addition, even if the references mainly appear in the footnotes, the theories do their work in the body of the text and are part and parcel of my analyses.⁷³

The examinations conducted in the next four chapters are guided by the questions: What is genetic diversity, and how is it produced in laboratories? And how does technology enable differences and similarities in the “socio-natural” world of laboratories where genetic diversity is being studied?

The four chapters are a collage. As in a collage, they show overlaps between technologies, scientists, scientific publications, laboratory practice, and focuses of analyses. As in a collage some pieces are cut out in order to focus more on others. For it is not the aim of this book to map all the different ways that genetic diversity is established, or all the technologies involved in achieving it, not even in the labs studied. The aim is to focus on some core practices, technologies and objects in studies of diversity and to

examine how they help to produce genetic similarities and differences. Given the research that is being conducted in the Diversity Project, the cases analysed here are therefore simultaneously narrower and broader than the scope of this project. Narrower because they do not take into account all the actors involved in producing genetic diversity. Broader because the technologies addressed also have relevance for other fields inside and outside the field of genetics.

Each chapter highlights a different feature of genetic diversity by addressing another practice of making similarities and differences. The chapters can be read in any order. The order I have chosen makes my own narrative of genetic diversity, namely that of standardisation, naturalisation and diversity.

The following chapter, Chapter 2 deals with *population*. In the Diversity Project population is *defined* according to linguistic criteria. In this chapter I examine *practices* and analyse what population is made to be in daily laboratory work. Chapter 3 investigates *genetic markers* (variable DNA fragments) and processes of standardisation. It examines the practicalities of genetic markers in laboratories in order to address issues of standardisation as envisioned in the Diversity Project. The case in Chapter 4 is a mitochondrial DNA *reference sequence*, a piece of technology to compare other sequences to. I examine the kind of work enabled by the reference sequence and trace what we might learn from that about naturalisation and about the normative content of technology. Chapter 5 is about *genetic sex and genetic lineage*. Here I investigate the various ways in which the sexes are enacted in studies of genetic lineage, and show how DNA is both treated as a resource of diversity and as a technology of establishing sexualised lineage. In Chapter 6, the concluding chapter, I take up the narratives about standardisation, naturalisation and diversity to reflect upon the analyses in the preceding chapters, and their relevance for STS, genetics, and gender and anti-racist studies.

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Notes to Chapter 1

1. Luca Cavalli-Sforza, quoted in Declan Butler, "Genetic Diversity Proposal Fails to Impress International Ethics Panel," *Nature* 377, no. 5 October (1995): 373.
2. For a criticism of this distinction between populations and of the idea that there exist populations that are pure, did not migrate and mix, see Richard C. Lewontin, *Human Diversity* (New York: Scientific American Book, 1995). He states: "The notion that there are stable, pure races that only now are in danger of mixing under the influence of modern industrial culture is nonsense" (Ibid., p113).
3. Leslie Roberts, "A Genetic Survey of Vanishing Peoples," *Science* 252, no. June 21 (1991): 1614-1617, p. 1614.
4. Luca Cavalli-Sforza, "Answers to Frequently Asked Questions About the Human Genome Diversity Project," (The North American Committee, 1993), p.2. This paper can also be retrieved on the Internet at <http://www.stanford.edu/group/morrinst/HGDP-FAQ>. The author of the Internet copy had become a collective, namely, "The Project's North American Committee." Moreover this copy is a revised version of the copy I received in 1995 from Professor Cavalli-Sforza. Here I refer to the early version of the paper.
5. See for example, see Paul de Stefano, "Genomics 101: The X's and Y's of Legal Rights to Genetic Material," *IP-Worldwide: The magazine of Law and Policy for High Technology* 101 (1996), at <http://ipmag.com/destefan.html>
6. Luke Holland (producer), *The Gene Hunters* (Zef Productions, 1995). This documentary was broadcast in June 1995 on Dutch television.
7. See for example Cavalli-Sforza, "Frequently Asked Questions" (above, n. 4), pp.5-6; David Dickson, "Whose Genes are they Anyway?," *Nature* 381, no. 2 May (1996): 11-14. On the debate about patents in relation to the Diversity Project, see Stefano, "Genomics 101" (above, n. 5).
8. In Holland, *The Gene Hunters* (above, n. 6).
9. RAFI 1993. See also Richard Tutton who analyses the fact that the European initiative has received some funding from the EC whereas the

North American initiative is still having trouble in terms of their preoccupation with culture and race. Whereas the North American initiative was engaged in a discourse on racism and anti-racism, the discourse of European initiative was more about culture and cultural heritage in the gene, see Richard Tutton, "Culture and Identity in European Genetic Diversity" (paper presented at the PFGS Colloquium 2, University College London, December 1998).

10. See, William J. Schull, "Correspondence," *Nature* 390, no. 20 November (1997): 221. Schull was chairing the NRC committee and his correspondence was written in response to a news report on the committee's findings, published earlier in *Nature*; see Collin Maclain, "Diversity Project 'does not merit federal funding'," *Nature* 389, no. 23 October (1997): 774.

11. Statement made by the population geneticist Kenneth Kidd about his work with Luca Cavalli-Sforza and other colleagues; Roberts, "Genetic Survey" (above, n. 3), p. 1616.

12. This is the title of a book about the ideology of genetics; Steve Rose Richard C. Lewontin, Leon J. Kamin, *Not in Our Genes* (New York: Pantheon, 1984).

13. In fact, different maps can be made on the basis of DNA, a genetic map and a physical map. Genetic mapping is technique through which the distance between genes and how they relate to one another can be determined. Physical mapping aims at determining the sequence order of the DNA. The goals of HGP is to determine both types of maps of the human genome.

14. Daniel J. Kevles, "Out of Eugenics: The Historical Politics of the Human genome," in *The Code of Codes: Scientific and Social Issues in the Human Genome Project*, ed. Daniel J. Kevles and Leroy Hood (Cambridge, Massachusetts: Harvard University Press, 1992), 3-37.

15. Walter Gilbert, "A Vision of the Grail," in Kevles and Hood, *Code of Codes* (above, no. 14), pp. 83-98, at p.96.

16. Kevles, "Out of Eugenics" (above, no. 14), p. 36.

17. Cavalli-Sforza, "Frequently Asked Questions" (above, no. 4), p. 2.

18. *Ibid.*, pp. 2-3.

19. See Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Issue of Human heredity* (Cambridge, Massachusetts: Harvard University Press, 1985), P. Menozzi L. L. Cavalli-Sforza, A. Piazza, *The History and Geography of Human Genes* (Princeton: Princeton University Press, 1994).

20. See for the power of myths and a critique of origin stories Donna J. Haraway, "A Cyborg Manifesto: Science, technology, and Socialist-Feminism in the late twentieth Century," in *Simians, Cyborgs and Women: The Reinvention of Nature*, ed. Donna J. Haraway (London: Free Association Books, 1991), 149-181.

21. Among these professors in genetics are Mary-Claire King at Berkeley, a former student of Wilson's; Ken Kidd at Yale, who has experience with the growing of cell lines; Ken Weiss at Pennsylvania State University, the chair of the North American committee.

22. HUGO, "Human Genome Diversity (HGD) Project: Summary Document," (Sardinia: 1993), p 1.

23. At this point it is important to indicate that there exist two conflicting ideas about human origin with consequences for the reconstruction of human migration history. The most frequently stated theory is the "Out of Africa Theory," the basic hypothesis of which is that all modern humans originated in Africa and colonised the world in one or more migration flows. A second and marginalised theory is the "Multiple Origin Theory," which assumes that modern humans sprang up in more places in the world and colonised different parts of the world simultaneously. For an example of this debate, see Alan G. Thorne and Milford H. Wolpoff, "The Multiregional Evolution of Humans," *Scientific American*, no. April (1992): 28-33, Allan C. Wilson and Rebecca Cann, "The Recent African Genesis of Humans," *Scientific American*, no. April (1992): 22-27. This ongoing controversy is usually reflected in scientific papers where geneticists tend to underline the fact that their results support the African origin theory. And so, now and then, a full paper is dedicated to making that point, such as C. Wills, "Another Nail in the Coffin of the Multiple-Origins Theory?," *Bioessays* 18, no. 12 (1996): 1017-1020; J. Hawks et al., "An Australasian test of the recent African origin theory using the WLH-50 calvarium," *Journal for Human Evolution* 39 (2000): 1-22.

24. HUGO, "Summary Document" (above, n. 22), p. 3, see also p. 2.

25. *Ibid.*, pp. 28-9. For the purpose of this pilot study a proposal competition was launched: "Pilot Projects for a Human Genome Project - Special Competition," to be found on the Internet at <http://web.ortge.ufl.edu>. This announcement welcomed proposals on: "Improving Techniques for Collecting, Preserving, Amplifying, and Selecting DNA Markers" and "Research on Ethical and Language Issues in a Cross-Cultural Setting."

26. See L. Luca Cavalli-Sforza, "The Human Genome Diversity Project," *ACTES: Proceedings* 2 (1995), p. 73.

27. See Tutton, "Culture and Identity" (above, n.9).

28. Roberts, "Vanishing People" (above, n. 3), p. 1615.

29. The professor of linguistics Colin Renfrew is for this reason very much involved in the Diversity Project. He participated in all the workshops organised by the Diversity Project, and was one of the chair-organisers of the Project's most recent workshop, held in Cambridge; *Human Diversity in*

Europe and Beyond: Retrospect and Prospect, Cambridge, Britain, September 9-13, 1999.

30. HUGO, *Summary Document*, (above, n. 22), p. 3; see also L. Luca Cavalli-Sforza, "Genes, Peoples and Languages," *Scientific American* November (1991): 72-78. Defining populations on the basis of linguistic separation is not new. This criterion was in fact introduced in the eighteenth century by Johan Fridrich Blumenbach, see Ivan Hannaford, *Race: The History of an Idea* (Baltimore, London: The Johns Hopkins University Press, 1996), especially pages 202-213; see also Stephen Molnar, *Races, Types, and Ethnic Groups: The Problem of Human Variation* (Englewood Cliffs: Prentice-Hall, Inc., 1975).

31. HUGO, "Summary Document" (above, n. 22), pp.12-13.

32. Cavalli-Sforza, "Genes, Peoples and Languages" (above, n. 30), p. 78. Moreover the correlation between blood groups and languages has already been claimed by C. D. Darlington in 1947, a claim that did not sustain criticism; C.D. Darlington, "The Genetic Component of Language," *Heredity* 1 (1947): 269-286 (quoted in Molnar, *Races, Types, and Ethnic Groups* [above, n. 30], p. 6).

33. See, Lewontin, *Human Diversity* (above, n. 2).

34. Part of the rhetoric of the Diversity Project concerning the sampling of these population and the urge to do this as soon as possible is connected to preservationist ideas. These populations are supposedly "vanishing" and "threatened by extinction," in a way losing their value for the purposes of the Diversity Project due to admixture. See Corinne P. Hayden for an elaboration of this rhetoric; Corinne Hayden, "Patently Natural: The Culture of Genealogy and the Nature of Biodiversity," (Santa Cruz: University of California, 1995), (also published in a slightly revised version as Corinne Hayden, "A Biodiversity Sampler for the Millennium," in *Reproducing Reproduction: Kinship, Power, and Technological Innovation*, ed. Sarah Franklin and Helen Ragoné (Philadelphia: University of Pennsylvania Press, 1998), 173-206.

35. HUGO, "Summary Document" (above, n. 22), p. 7.

36. I thank Paul Wouters for bring this point to my attention.

37. Examples of such studies are numerous, but a rather political example presented in a document of the Diversity Project is the following: "One example would be studying Siberian populations to determine whether they manifest any attributes of the susceptibilities of Native Americans to diabetes." (HUGO, "Summary Document" [above, n. 22], p. 13).

38. *Ibid.*, p. 28, Cavalli-Sforza, "Diversity Project" (above, n. 26), p. 75.

39. HUGO, "Summary Document" (above, n. 22), p. 17.

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40. Ibid., p. 3, 20, see also Cavalli-Sforza, "Diversity Project" (above, n. 26), p. 74.
41. Ibid., p. 74, HUGO, "Summary Document" (above, n. 22), p. 22.
42. Polymerase Chain Reaction (PCR) is the current cloning technology, developed at the end of the 1980s and well established in the early 1990s. About the need for standardisation see: Cavalli-Sforza, "Diversity Project" (above, n. 26), p. 74, HUGO, "Summary Document" (above, n. 22), pp. 3-4.
43. See on how technology is implicated in research conducted in the HGP; Kevles and Hood, *Code of Codes* (above, n. 14); see also Paul Rabinow, *Making PCR: A Story of Biotechnology* (Chicago, London: The University of Chicago Press, 1996). Especially in the introduction Rabinow articulates this central role of technology in the Human Genome Project and its implications for his own project.
44. HUGO, "Summary Document" (above, n. 22), p. 3.
45. Ibid., p. 4. For criticism of the Diversity Project's ideas of "vanishing" and preservation of genetic heritage, see Hayden, "Patently Natural" (above, n. 34), pp 9-10.
46. See also Donna Haraway. She points out how much easier it proved to slow down or stop the Diversity Project by opposition, compared to the much more powerful HGP; Donna J. Haraway, Modest_Witness@Second_Millennium.*FemaleMan*[®] *_Meets_OncoMouse*[™] (New York, London: Routledge, 1997), p. 250.
47. For example, the so-called "Blue Mountain Declaration" of February 1995, <http://www.indians.org/welker/genome.html>, and the WWW site of the "Indigenous Peoples Coalition Against Biopiracy;" <http://www.niec.net/ipcab>; see also "Worldwide Forest/ Biodiversity Campaign News," <http://forest.lic.wisc.edu>
48. For the post-war debate on biological race and racism, see, UNESCO, *UNESCO and its Programme III: The Race Question* (Paris: UNESCO Publication 785, 1951); UNESCO, "The Race Concept: Results of an Inquiry," in *The Race Question in Modern Science*, ed. UNESCO (Paris: UNESCO Publication, 1952), 36-91. For an elaboration on both statements, how they are intertwined with feminist politics, and for situating some of the scientists involved, Donna Haraway, *Primate Vision: Gender, Race and Nature in the World of Modern Science* (London, New York: Verso, 1992 [1989]), especially at, 197-206. On bad science as a post-war category, see in addition to Haraway also Kevles, *In the Name of Eugenics* (above, n. 19)
49. Controversies are indeed interesting objects of research because they generate lots of material and documents and destabilise scientific facts. Controversies reveal the various networks of people, things and ideas involved in scientific facts. Facts that seem hard open up both inside and

outside laboratories because they become topics of debate and show their moulded, fabricated, decided-upon features. Thus controversies also disrupt the ordinary, often tedious, get-the-data kind of laboratory work; see on controversies in science studies, Rob Hagendijk, "Wetenschap, Constructivisme en Cultuur" (University of Amsterdam, 1996), Brian Martin and Evelleen Richards, "Scientific Knowledge, Controversy, and Public Decision Making," in *Handbook of Science and Technology Studies*, ed. Sheila Jasanoff, et al. (London, New Delhi: Sage Publications, 1995), 506-531, see also Bruno Latour, *Science in Action: How to follow Scientists and Engineers Trough Society* (Cambridge, MA: Harvard University Press, 1987). For a variety in approaches towards the Diversity Project, see Joan Fujumura and Richard Tutton's focuses on the concept of culture, Joan Fujumura, "Creating "Cultures" in Debates About Genomes, Information, and Diversity" (paper presented at the Postgenomics? Historical, Techno-epistemic and Cultural Aspects of Genome Projects, Berlin, 8-11 July 1998), Tutton, "Culture and Identity" (above, n.9); Corinne Hayden's focus on kinship and diversity and Donna Haraway's focus on purity and contamination, Hayden, "Patently Natural"(above, n. 34), Haraway, *Modest_Witness* (above, n. 46), pp. 213-265.

50. Needless to say, this notion is not my own idea. Various debates in studies of science and technology have been held. For example, there is a whole tradition within gender and anti-racist studies in which the ontological distinction between the object and the subject of research has been questioned. Scientists do not "discover" an object (be this nature or the female body) they have argued, but make it into one and "reduce" it to some variables or qualities that can be studied. Additionally, more recently and from a different political angle, but with a similar conclusion, scholars who have been studying the process of scientific research have shown that objects do not exist by themselves, but are dependent on the very scientific practice in which they are studied.

51. On standardisation of DNA technologies in order to make them work in different places see, Joan Fujimura, "Crafting Science: Standardized Packages, Boundary Objects, and "Translation"," in *Science as Practice and Culture*, ed. Andrew Pickering (Chicago: University of Chicago Press, 1992), 168-211.

52. For an overview and discussion of the early laboratory ethnographies, see Karin Knorr-Cetina, "The Ethnographic Study of Scientific Work: Towards a Constructivist Interpretation of Science," in *Science Observed: Perspectives on the Social Study of Science*, ed. Karin Knorr-Cetina and Michael Mulkay (London: Sage, 1983), 115-140; Karin Knorr-Cetina, "Laboratory Studies: The Cultural Approach to the Study of Science," in Jasanoff et al., *Handbook*

(above, n. 49), pp.140-166, Michael Lynch, *Scientific Practice and Ordinary Action: Ethnomethodology and Social Studies of Science* (New York, Melbourne: Cambridge University Press, 1993).

53. Thomas Kuhn, *The Structure of Scientific Revolution* (London, Chicago: The University Of Chicago Press, 1970 [1962]).The laboratory is also a theoretical notion. A nice twist lies in the fact that a powerful site of western culture, deeply embedded in society, and with ever further-reaching links between domains, is made local and strange through laboratory studies. Instead of science being addressed as the temple of rationality, it is addressed as the specific, that should be understood in terms of a local culture. Furthermore laboratories are not just seen as a space where the scientist investigates the object but as a locale with an agency in itself, ordering and transforming objects and scientists and making specific alignments between them. In the context of a laboratory neither the scientist nor the object can be seen as a stable entity. They are linked in specific ways so as to get the job done; see Knorr-Cetina, "Laboratory Studies"(above, n. 52). On the lack of stability of entities (bodies) or, better, on how the various bodies (including that of the surgeon) have to be performed in specific ways in an operating theatre see, Stephan Hirschauer, "The Manufacture of Bodies in Surgery," *Social Studies of Science* 21 (1991): 279-319.

54. Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (Princeton: Princeton University Press: Princeton, 1986 [1979])

55. See for various examples, Andrew Pickering, *Science as Practice and Culture* (above, n. 51).

56. This difference between fields is both artificial and real. Despite important overlaps it seems that both social studies of science and gender studies are living in separate spheres. For example feminist scholars have been wary of laboratory studies and studies that have science as their main focus. They argued that now that immense energy had been spent to reveal women in the history of science, especially as women objects of science, studies of laboratories are redirecting attention to domains populated mainly by men. Another reason for the separate spheres is that in the social studies of science little effort has been made to address gender, let alone racial, issues. But also the other way round. For many feminist scholars "science seems to be in action" in a relevant sense, when it deals with women, women's lives, sexuality and biology, or with female bodies. In contrast to this, Donna Haraway in a fascinating lecture wittily told a history of science and technology studies (STS) from a feminist point of view. The twist was in the very treatment of STS as a branch of feminist studies and not the other way round. In her genealogy the beginning of STS could be located in the

late 1960s and early 1970s, when women started to demand reproductive freedom. She quoted feminist contributions, from the early pamphlets on to the various scholarly works being produced until the late 1990s, and the importance of that for the development of STS as a field; Donna Haraway, "Feminist Science Studies: A history of STS from a Feminist Point of View" (paper presented at the WTMC Summer School, Enschede, September, 1-5 1997).

57. See for an example on sexual biases in biology, Linda Birke, *Women, Feminism and biology* (Brighton, Sussex: Wheatsheaf Books, Harvester Press, 1983); on race see, Richard C. Lewontin, Steven Rose, and Leon J. Kamin, *Not in Our Genes* (New York: Pantheon, 1984), Linda Gordon, *Woman's Body, Woman's Rights: A Social History of Birth Control in America* (New York: Viking, 1976), idem, "De Strijd voor Vrijheid van Reproductie: Drie Stadia in het Feminisme," in *Socialisties Feministische Teksten* (Nijmegen: Feministische Uitgeverij Sara, 1979), 36-72; For an example of gender bias in the language of science, see Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, CT: Yale University Press, 1985), idem, *Secrets of Life, Secrets of Death: Essays on Language, Gender, and Science* (New York: Routledge & Kegan Paul, 1992).

58. See for a good example of the eggs and the sperm Emily Martin, "The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male-Female Roles," *Signs* 16 (1991): 485-501; see on the distribution of agency to the cytoplasm/germ plasm, Evelyn Fox Keller, "The Problem of Locating "Maternal Effect" in a Discourse of Gene Action," (Amsterdam: University of Amsterdam, 1992), (revised and published in Evelyn Fox Keller, *Refiguring Life: Metaphors of Twentieth-Century Biology* [New York: Columbia University Press, 1995]).

59. See for examples, Evelyn Fox Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (San Francisco: Freeman, 1983), Darlene Clark Hine, "Co-Laborers in the Work of the Lord: Nineteenth-Century Black Womanhood," Sandra Harding, *The Racial Economy of Science: Towards a Democratic Future* (Bloomington, Indianapolis: Indiana University Press, 1993), pp. 210-227, and a special issue "'Zy is toch wel zeer begaafd.'" *Historische Bijdragen over Vrouwen in de Bètawetenschappen*," *Gewina* 4 (1997).

60. See for some examples of these approaches, Jan Harding, ed., *Perspectives on Gender and Science* (London, New York: The Falmer Press, 1986), Ruth Bleier, ed., *Feminist Approach to Science* (New York, Oxford: Pergamon Press, 1988), Harding, *Racial Economy of Science* (above, n. 59). In most cases, however, contributions in this fields resist the methodological distinctions (language, sociology, and method) that I try to force on them

here. Consider for example Evelyn Fox Keller's work, which obviously deals with language and metaphors in science, but hardly ever treats this separately from form methods of science.

61. Within science and technologies studies, questions of normativity and technology are most persistently articulated by Donna Haraway, John Law Annemarie Mol, Susan Leigh Star.

62. For a collection of studies from this angle, see Susan Leigh Star, ed., *Ecologies of Knowledge: Work and Politics in Science and Technology* (Albany: State University of New York Press, 1995); see also, John Law, "After ANT: Complexity, Naming, and Topology, in *Actor Network Theory and After*, ed. John Law and John Hassard (Oxford: Blackwell Publisher, 1999), pp. 1-15.

63. For a very elegant example that deals with normalisation and naturalisation, see Charis Cussins, "Producing Reproduction: Techniques of Normalization in Infertility Clinics," in *Reproducing Reproduction: Kinship, Power and Technological Innovation*, ed. Sarah Franklin and Helena Ragoné (Philadelphia: Pennsylvania Press, 1998), 66-101; on standardisation and marginalisation see the by now classic paper of Suzan Leigh Star, "Power, Technology and the phenomenology of Convention: On Being Allergic to Onions," in *Sociology of Monsters: Power, Technology and the modern World*, ed. John Law (Oxford: Basil Blackwell, 1991), 26-56; for an excellent example on personhood see, Ingunn Moser and John Law, "What Makes a Person?" (paper presented at the EASST Conference, Lisbon, 1998), idem, "Good Passages, Bad Passages," in Law and Hassard, *Actor Network* (above, n. 62), pp. 196-219; on performing the sexes and its articulation in technologies see the clever and humorous paper of Annemarie Mol and Stephan Hirschauer, "Shifting Sexes, Moving Stories: Feminism Constructivism Dialogues," *Science, Technology & Human Values* 20 (1995): 368-385; on how masculinity and Euro-American concepts of kinship are implicated in computer simulation see, Stephan Helmreich, "Replicating Reproduction: Or, the Essence of Life in the Age of Virtual Electronic Reproduction," in *Reproducing Reproduction: Kinship, Power and Technological Innovation*, ed. Sarah Franklin and Helena Ragoné (Philadelphia: Pennsylvania Press, 1998), 207-234; on sex and gender see also Stephan Hirschauer, "Performing Sexes and Genders in Medical Practices," in *Differences in Medicine: Unravelling Practices, Techniques and Bodies*, ed. Marc Berg and Annemarie Mol (Durham N.C.: Duke University Press, 1999), 13-28; on the body and its articulation in instruments and technologies see, Nelly Oudshoorn, *Beyond The Natural Body: An Archaeology of Sex Hormones* (London, New York: Routledge, 1994); Hirschauer, "Manufacture of Bodies" (above, n. 53), Annemarie Mol,

The Body Multiple: Ontology in Medical Practice (Durham, N.C.: Duke University Press, forthcoming).

64. An exception to this is Sharon Traweek's study on gender and high-energy physics, see for example Sharon Traweek, "Border Crossings: Narrative Strategies in Science Studies and among Physicist in Tshukuba Science City, Japan," in *Science As Practice and Culture*, ed. Andrew Pickering (Chicago, London: The University of Chicago Press, 1992), 429-465, idem, "Pilgrim's Progress: Male Tales Told During a Life in Physics," in *The Science Studies Reader*, ed. Mario Biagioli (New York, London: Routledge, 1999), 525-542.

65. For a similar argument, see Susan Leigh Star, "Introduction," in Star, *Ecologies* (above, n. 62), pp. 1-39..

66. Donna Haraway expresses it as follow: "It has proved easier to slow down or stop the HGDP [the Diversity Project, AM], a kind of oppositional effort, than to question the powerful HGP itself. That makes the trouble with "difference" built into this potentially positive scientific project all the more disturbing - and important" (Haraway, *Modest_Witness* (above, n.46), p. 250.

67. *Human Genome Variation in Europe: DNA Markers*, 9-10 November 1995 in Barcelona.

68. For an articulation of this particular fear of the researcher of science, namely not to be where the action is, see John Law, *Organizing Modernity* (Oxford, Cambridge: Blackwell, 1994); pp. 45-47. idem, "After ANT: Complexity, naming, and Topology," in John Law and John Hassard, *Actor Network Theory and After* (Oxford: Blackwell Publisher, 1999), p. 1-15, at p..

69. For a similar account, see Star, "Introduction" (above, n. 65). There she states the following: "As a group of respondents, scientists are particularly difficult and rewarding because they have often thought rigorously about the issues we are investigating, and about which we are ourselves uneasy" (ibid., p. 8).

70. On the ordering of both the ethnographic work as well as the ethnography, see, Law, *Organizing Modernity* (above, n. 68), see, also Traweek, "Border Crossings" (above, n.64); for an example of how to deal with methodology, see Annemarie Mol and Jessica Mesman, "Neonathal Food and the Politics of Theory: Some Questions of Method," *Social Studies of Science* 26 (1994): 419-444.

71. See for a thorough and elegant treatment of this, Clifford Geertz, *Works and Lives: The Anthropologist as Author* (Cambridge: Polity Press, [1988] 1996).

72. For this debate in the field of anthropology, see James Clifford and George Marcus, eds., *Writing Culture: The Poetics and Politics of*

Ethnography (Berkeley, Los Angeles: University of California Press, 1986); for examples in the field of STS see, Law, *Organizing Modernity* (above, n.68), Traweek, "Border Crossings" (above, n. 64).

73. See also Traweek, "Border Crossings" (above, n. 64), and Law, *Organizing Modernity* (above, n. 68). Specifically on the on the normativity of both author and object of research, and the normativity of the method of research and one's writing, see Mol and Mesman, "Politics of Theory" (above, n. 70)