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

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Chapter 6

Technologies of Similarities and Difference, 
Or How to Do Politics With DNA

This book has dealt with the socio-materiality of genetic diversity in the era of the Human Genome Diversity Project (the Diversity Project). It started off by asking what population is, did the same for technology, then went on to consider the autonomous nature of technology and finally that of DNA. Four cases and a few more practices have been examined. The localities investigated were laboratories. Both scientists and DNA were deliberately kept out of focus. Many other aspects were placed centre-stage. Technologies, individuals, populations, lineage, gifts, races, sexes and blood — among others things — have been passed in review. They were integral parts of the fabric of the laboratories studied. The analyses made examine a heterogeneity of technologies and practices and how these affect the object of geneticists’ research. Now it is time to make some links that go beyond each individual case and to narrate stories that reach beyond the Diversity Project. I would like to tell three stories, each of which aims at embedding the results of my research in other academic fields: science and technology studies (STS), population genetics as related to the Diversity Project, and gender and anti-racist studies.

Naturalisation: Tracing the Politics of Nature and Technology

Story 1: talking back to STS

This book is a laboratory study. Such studies are not new in STS. Laboratory studies have been part of the scene ever since the late 1970s. Having studied the Diversity Project in laboratories I would not want to argue that these are privileged sites for studying genetics. Laboratories were rather chosen as a point of contrast to the global discourse of the Project.¹ Whereas the goal of the Diversity Project is to map what is out there, namely the diversity of the world’s populations, my aim was to investigate the locally-achieved character of genetic diversity in the process of laboratory
conduct. These localities did, indeed, allow me to show that neither DNA nor scientists work by themselves. In addition, the localities showed that laboratories are not isolates, producing exotic kinds of knowledge, nor are they easily taken up in a global endeavour, to become dislocated spaces. Laboratories do not meet the classic distinction between local and global\textsuperscript{2}. They are best seen as sites of interference, of discourses, practices and technologies of various kinds. Thus rather than a unified and a well-ordered process, the work of laboratories can be understood as the management of contingencies.\textsuperscript{3} The heterogeneity of such practices is in itself enabling: it allows for the making of new links, the solving of practical problems and the establishing of lineages between labs.

So far, so good. At least for an STS audience there is nothing strange going on here. However my goal was not to map out the work of the laboratories or the organisation of science in the Diversity Project as such. My interest lay in analysing the very topic of the Project, namely genetic diversity. How is genetic diversity practised? What have we learned about it from the daily work in the laboratory? And what kinds of story did the analyses in the different chapters together produce about that work? One of the stories narrated in this book is that of naturalisation. Let us take it up again here.

- Is there such a thing as a natural object – say, population?

Population is not just any odd category. It is crucial to population genetics, its major object of study. In the introduction we saw that population was a matter of debate, also within the confines of the Diversity Project. Thus I went into what population “is.” The first thing I hit upon was how geneticists define it, namely on the basis of linguistic separations. The second was how it is practised in laboratories. That was something I examined specifically. In analysing a forensic case I showed that population is not one unified category. In this case at least seven different versions of populations were practised and were shown to be dependent on technologies and practices. In the laboratory, population may be the box of samples that happens to be in the freezer, or a post-war racial distinction that is part of scientific discourse, or the number of genetic markers being used. This does not, however, imply that different technologies produce different insights about a pre-existing object. Population is neither a matter of nature, one that can be discovered, nor a matter of definition, which more or less represents a detached object. What population is depends very much on the practices in which it is studied and the technologies applied to it. Moreover the different versions of population that may be enacted in a laboratory do not necessarily add up to produce a better “re-presentation” of population. As was shown in this particular case, the different versions practised might even conflict. This
very fact underscores the heterogeneity of laboratory practice, because the versions of population just might as well not exist in such practices. Since versions of objects, such as population, do not exist by themselves, it is in this heterogeneity that different and even conflicting versions may be actively performed. This suggests that rather than a matter of a unified approach to population, the latter is a matter of laboratory practice. In laboratories, technologies are at the centre of DNA research. Thus, rather than a "natural" object, population is a technology-enabled object.

- If genetic objects are matters of technology, what then is technology? Laboratories are full of technologies. To answer the question of what technology is, I focused on genetic markers and examined how they were applied in laboratory practice. In a DNA-based genetics, markers are the tools of comparisons between individuals or population. They allow for comparisons based on differences. As I argued, in such practice people are not so much related by blood or by DNA but by genetic markers. But what is a genetic marker? The definitions describe markers as DNA fragments containing specific information; a marker is thus an object of comparison based on information in the DNA. In the laboratory, however, a marker is performed as a protocol, informing the technician how to go about an experiment. At the workbench it is practised as chemicals added to a solution, as a PCR program to copy a specific DNA fragment, as particularities of such a fragment or as a technology to visualise it. These practices all contribute to or inhibit possibilities of applying it as an object of comparison. At the workdesk a marker is performed as data and, depending on specific goals, as information about population. These various ways of practising markers indicate that the markers are not only objects of research but also technologies for studying diversity. Moreover my analyses suggest that in laboratory practice a marker is best understood as a socio-technical network in which humans, technical devices, chemicals, texts and DNA are aligned, and which together constitute what a marker is. Specifically, when a marker starts to travel between labs the significance and the mutual effects of all these components becomes apparent. Thus the answer to what a marker is points in the direction of scientific work and how it is organised. Rather than an entity, a genetic marker is a technical network in a scientific practice. This network may become more or less solid, contributing to the standardisation of a marker, or it may remain more or less fluid, allowing for its flexibility and alignment to other practices.

- If technologies are socio-technical networks, why do they appear autonomous?
The answer to this question is related to the issue of naturalisation. In this study I have investigated a technical device and its naturalisation. This standardised device is a DNA reference sequence, the so-called Anderson sequence. Just like genetic markers, it is a particular piece of technology. At the same time as being a technology that appears on a computer screen as a text, it is also an object, produced in 1981 on the basis of human tissue.

In its capacity of reference sequence it is applied as a means of comparing individual sequences and as the terms in which these sequences are expressed. Being a text, which consists of 16,569 characters/letters representing the nucleotides, it moves smoothly and is virtually available to any laboratory in the world. This does not, however, explain its success or its naturalisation. Looking at the kind of work it enables in laboratories, I have shown that its functioning as the standard is dependent on the reification of a specific DNA practice, that of sequencing DNA and comparing the sequences. Thus its usefulness as a technical device depends on how DNA is handled in laboratories. Yet in these practices it is applied as more than a technical device to produce and compare sequences: it is also treated as the source from which any other sequence has evolved, since DNA sequences are said to contain mutations from the Anderson sequence. One could say that it is treated as the reference sequence not only by convention but also by nature. Investigating how this object of comparison was produced, I have shown the kind of practices, technologies and tissues it embodies, and how it carries them along while travelling between laboratories. My analyses show that its ongoing success in various laboratories is not only indebted to the organisation of DNA research in such practices but also to the theory of DNA inheritance, the theory which treats all individuals as part of one genealogical family. It is with the help of this theoretical device that the Anderson sequence occupies the place of a natural object, and in a very practical sense comes to stand for the sequence from which all other sequences evolved. Hence the practicability of Anderson and its treatment as an autonomous object in the laboratory is due not only to how DNA is handled but also to how sequences are analysed, i.e. which theory is being applied to accomplish this. Thus naturalisation of technologies is a matter not only of standardisation but also of a unified “world view” in a scientific field.

The traffic in things is common practice in laboratory work and the alignment of humans, objects, technical devices and theories is part of making things work. Where, then, lies the problem of naturalisation? This problem is not so much in the fact that technologies are locally produced and that they embody specific practices. Rather the problem lies in the treatment of the results enabled by them. What is naturalised in the case of Anderson is not only the reference sequence itself, as a kind of original sequence, but also
all the similarities and the differences produced through comparison to it. In what follows I will address why this is a problem.

- So technologies are socio-technical networks which, with the help of unifying theories, may be treated as "natural". But might this also hold for the objects of genetics, such as population or DNA? After all, both genetic markers and the Anderson sequence are objects as well as technologies. This question is addressed in my examination of genetic sex in studies of genetic lineage. Just as in the case of population, in genetic practice there are various different ways of enacting the sexes. The relevance of sex difference and the way the sexes are performed depends on technologies and also has consequences for population. One could say that in laboratory practice both the sexes and population are denaturalised and their heterogeneity is appreciated. The open-endedness of research requires that different versions of such objects are enacted in the process of study. It enables new links, in terms of analyses or research strategies. However placed in the context of genetic lineage and studies of population history the different versions of the sexes are subordinated and data based on sex difference come to stand for people: men, women and populations. This indicates that in the process of making universal claims about genetic lineage, not only technology but also genetic objects and the similarities and differences between them are naturalised. Thus naturalisation of technology is indeed a matter of concern because it helps essentialise similarities and differences produced by such technologies.

Should this lead to the conclusion that geneticists in the Diversity Project tell an old story with new means? I think the answer should be both yes and no, and this is exactly the trouble with genetics. It depends on which story is being told, that of human-migration history or that of populations. Whereas in the first case population is treated as a passage point of specific genetic information (the vehicles for the spread of genes), in the second it is treated as the embodiment of similarities and differences. Ironically enough, population tends to be naturalised in the former and heterogeneously configured in the latter. This has to do with the difference between studies of genealogy and human evolution and studies of populations. I will elaborate on this below.
Standardisation: Tracing the Normativity of Practices

Story 2: talking back to Genetics

The fate of scientific results is in the hands of their future users. Geneticists will be the first to subscribe to this statement. Ever since the Second World War population geneticists have become sensitised to the consequences of science. In the face of looming technological potential, questions about “effects” of genetics are being raised, even in laboratories. These questions may not only concern racial issues but also the possible psycho-social effects of paternity testing or genetic diagnostics. Here I want to pick up on these moral issues not by taking the questions a stage further but rather by setting them back a step in the trajectory of scientific conduct. In fact the question here is: what would happen if we decided not to make a separation between the worlds of producers and those of users? What would happen if we took the producers of scientific results to be their very users? Instead of following the facts outside the labs, I turned my attention towards what happens in those locales. It was there that I wanted to learn about the stuff that genetic diversity was made of. What it entails and how it is enabled by technology were my leading concerns. But what moral issues did my analyses uncover and what can we learn from these in debates about the Diversity Project?

Working together requires common ground. Geneticists are aware of that. They are also aware that the work to achieve common ground is not only done by people but also by technologies. This is even more so if the aim is an international project. Hence the topic of two conferences, organised within the Diversity Project in the early 1990s. Geneticists participating in the project agreed on the terms of reference concerning technologies to be used and the concept of population to be applied. The aim was to standardise both genetic markers and population so as to facilitate the exchange of results and their comparability. However standards are by no means neutral and their effects may well go beyond the convenient. Therefore the second story that I want to narrate is about standardisation. I want to focus on that, also to redistribute some of the moral/normative questions that have been raised within the Diversity Project.

- Given the aim of making a genetic map of the world, one of the first issues raised within the Diversity Project was that of population. As indicated above, geneticists decided to define it on the basis of linguistic differences. However my analyses of how population was practised showed that what population was made to be in laboratories varies. I suggested that the various ways in which population was enacted had advantages in such
locales because of the heterogeneous nature of laboratory work. In laboratories geneticists are not working on mapping the world but on various different and more specific questions. In addition the organisation of science is based on problem-directed collaborations, rather than general aims, a fact which may contribute to how population is practised. For example, the traffic in samples between laboratories establishes lineages between these laboratories, and these lineages in their own right have implications for which version of population might enter the laboratory.

Does this mean that what population is made to be is a local matter and cannot be standardised? The answer to this depends on where the action is located. If one considers the process of experiments, at the workbench, then the answer to whether practices of population are standardised is negative. However various versions of population that may be found there do not exist in isolation. For example, population on the basis of family names may be a product of collaboration between laboratories, and may thus be found in Leiden, Berlin and/or Vienna. Standardisation is thus established as a result of the organisation of scientific work and is a product of interfering scientific networks. This also indicates that such a standardised approach to population does not necessarily prevent the occurrence of other versions of it.

In addition to this, standardisation is also established in how the results leave the laboratories, in the form of evidence in a scientific paper or as information to be stored in the databanks. My examination of scientific papers shows how data are analysed and how results from different population studies are made comparable, suggesting that standardising and comparing populations is achieved in retrospect. Given the aim of the Diversity Project to standardise what population “is,” one could say that the process of standardisation is not so much achieved through the collection of samples or through the practice of studying these at the bench. It is rather achieved in the practice of making populations comparable, whether this be the practice of modelling population data (in papers) or that of data retrieval (in databanks).

• If standardising what population is, is a matter of interference between networks, how does this affect technology?

The availability of technologies such as PCR and genetic markers is adjudged to smooth the path for diversity research. Markers are a new phenomenon of post-PCR genetics. Not that markers were not there before the 1980s, but they have only been available in large numbers since the advent of PCR, a fact which contributes to the various different ways of studying genetic diversity. Especially since their number is growing almost daily, geneticists have agreed on a list of markers for the Diversity Project.
This list prioritises the use of specific kinds of markers over others, and in fact aims at standardising their daily use in laboratories. Taking into account how markers are applied in practice, I showed that they are dependent on the alignment of various constituents. A marker might just as well be a DNA fragment and the variability it might contain, various chemicals and a polymerase enzyme, a copying technology and the PCR program to run it, visualising technologies, a protocol or a routine way of doing things in the laboratory. Establishing these alignments in one routine practice does not guarantee the success of a marker in other places. The analysis of a case of chimp DNA typing showed that genetic markers carry such practices along with themselves while travelling between laboratories. The question of whether a marker could be applied for a diversity study of chimps was shown to depend on both the reification of the practices embodied in a genetic marker and on the specific goals of the studies. This indicates that technology may be to hand and may be standardised by convention, but to make such a technology work in a local setting requires a great deal of work, investment and time. It is the success of such collective socio-technical work that makes a technology into a standard.

This is the kind of socio-technical work that biotechnology companies are trying to make less of a burden. In a way such companies aim at solidifying the socio-technical network that makes up a marker by providing marker kits for genetic research. These kits usually consist of a cluster of markers, and the various experimental steps necessary for their visualisation are usually reduced in number. They are therefore considered time-saving. However a complaint frequently heard from practitioners is that not only are commercial kits very expensive, putting constraints on which laboratories can afford to use them, but also the protocols that come with the kits hardly economise on the reagents. Laboratories, therefore, find themselves investing time both in making the kit fit their laboratory conditions and in optimising and changing the protocols in order to save on the reagents. The example of commercial kits indicates that the locally achieved character of technology and the fact that it does not travel so easily does not mean that its fluidity cannot be "captured" into a more stable form. It does not mean that technology cannot be solidified. Laboratories are overpopulated by frozen moments of collective socio-technical work, in the form of chemicals, equipment, machines and texts. Yet any kind of technology does not only co-determine who may or may not become its future users: it also has to be established in a specific local setting. In addition the various different tasks carried out in a laboratory and their specific configurations of practices also determine the applicability of markers in such a context. For example, studying genetic diversity in a forensic DNA practice or in a combined practice of forensic DNA and paternity testing may co-determine the sets of
markers applied in a laboratory. Placing this back in the context of the Diversity Project and its aim of standardisation suggests that local settings and laboratory practices for making markers work might put constraints on which markers will become part of its “priority list,” and thus on what will become a standard.

- The Diversity Project has encountered much criticism and has been accused of being racist because of its special interest in indigenous peoples and isolated populations. This criticism has been rejected by leading scientists in the project who see the project as a potential means of fighting racism by “proving” that there is no such thing as biological human races. Moreover the Diversity Project was initiated as a response to the Human Genome Project, which aims at mapping and sequencing one human genome. This sequence genome, based on the DNA of four to five individuals, was deemed to be Eurocentric by population geneticists. They therefore suggested a project to map human genetic diversity on a worldwide basis. Hence the Diversity Project. In the debate about race and racism in the Diversity Project, on which I elaborated in the introductory chapter, my aims have been to take the examinations beyond the discourse of good and bad scientists or good and bad “genes.” Race and racism, in fact, do not only matter in terms of good or bad intentions, but especially and most disquietingly in various practices, objects and technologies which escape the notice of their daily users and which seem so convenient and benign. Here lies the puzzling matter-reality of race and racism. As I pointed out in the introductory chapter, the politics of science, just like the politics of racism and science, is either treated as an anathema or debated in terms of good versus bad science, the latter being a way of saying that whether science is good or bad depends on the ditto intentions of the scientist. In tune with this approach to the politics of science, race and racism would be merely excesses that could be removed surgically to obtain a “neutral” field. One of the problems with this idea of politics is that it fails to take into account how – in this case – race materialises in the interactions between humans and things. Additionally it would take away the opportunity to investigate how race or racism are produced in routine practices, in practices where “nothing strange seems to be going on.” Throughout this book I have focused on routines, on how technologies act on practices and help produce specific versions of objects. Race is no exception in that respect. Any object is enabled, not only by the work of scientists but also by that of technologies, language and other practicalities. Given these considerations I find it important to bring technology, and especially routine and standardised technology, into the debates about race and racism.
The blunt and obvious nature of standards has interested many social scientists and philosophers, particularly because of the question of whom or what they might include or exclude.\textsuperscript{14} In my examination of the Anderson sequence I focused on inclusion and exclusion and showed how racial bias comes to be built into such a standard technology. Taking into account the kind of tissue and technologies that were applied to sequence Anderson, I have shown that this bias was not so much the effect of ideology but especially that of technology. In addition my examination of the different sources of DNA used for Anderson showed how race was made relevant in specific practices of genetics and not in others. The same tissue used for the reference sequence was racialised in other practices, but not in that of Anderson. However by taking into account the way Anderson was made it was possible to show its investedness by technologies and its normativity in terms of race, qualities that it did not lose by becoming a text. Yet in laboratory practices this normative content seemed to be absent and, as a locality of racial biases, obscured. My point here is this. The endeavour of the Diversity Project is dependent on standardisation and a great deal of effort is put into achieving that for technology. Anderson is a case of a standardised technology. Yet the thrust of my analysis is not that technologies would or could be free of any biases. Technologies are always produced somewhere and can never be neutral. The point is rather that Anderson provides an example of how standardisation obscures the normativity of technologies and the "ideological" content of the practices that helped produce them. This working of standards has implications for the objects that they help produce.

- The statement that "there is no such thing as race," is not enough.\textsuperscript{15} The Diversity Project cannot escape a world where race and racism are realities experienced by the majority of people. Nor can scientific facts by themselves transform practices, especially those practices outside the scope of the Project.\textsuperscript{16} This indicates that, rather than a universal claim that refers back to the diversity in the "genes," we need answers about the diversity of "genes," that is about the various different ways in which genes and genetic difference \textit{can} be established. What is needed is a bringing to the surface of the diversity of scientific practice. And, given the heterogeneity in scientific practice, genetics may indeed contribute to the denaturalisation of differences.

The analyses offered in this book show that genetic objects are products of the practices in which they are studied, and reveal how that takes place. Nevertheless, as I have shown, results of diversity research tend to be naturalised. In that process, the discourse of the Diversity Project oscillates between the practice of \textit{genealogy} and gene pools and that of \textit{populations}.
Whereas in the first case populations are treated as resource and passage points of genetic information, in the latter case populations are treated as collections of individuals providing insight into the diversity in such groups. I stated above that population tends to be naturalised in the practice of genealogy. How does that take place? In a practice of genealogy geneticists aim at studying the migration history of humans and estimate moments in history when contemporary “populations” diverged or coalesced. The analysis of specific clustering of genetic similarities and differences between “populations” for that purpose requires that geneticists estimate the mutation rate in the DNA, i.e. how differences have evolved through time. In order to do this, DNA – or, better, specific parts of the DNA – are said to be molecular clocks. This clock ticking equally fast in all individuals suggests that DNA changes equally fast. Specific parts of the DNA are thus treated as standardised technologies which help geneticists to read genetic similarities and differences and establish the history of “populations.” Hence, in the practice of genealogy, similarities and differences in the DNA become part of a master narrative about population. The very treatment of DNA both as a standardised technology and as a natural resource accounts for the quasi-monitoring of diversity through history and for the naturalisation of population and population lineages. In a practice of population, however, different DNA systems or technologies are taken into account. Such studies attend to various different ways of clustering population and question it as a homogeneous object. Moreover such studies tend to pose questions about the past of a population rather than fitting the data into pre-existing accounts of history and lineage. Comparing two population studies, I have shown that a focus on the populations being studied leads scientists to question a standardised mutation rate, as well as pre-given clustering of these populations. Hence in the process of studying various DNA systems in the practice of population, the very concept of population is denatured. However due to the preoccupation of geneticists with human-migration history, the heterogeneity tends to be subordinated and population tends to be naturalised and practiced as “race.” And this should concern geneticists in the Diversity Project, especially those engaged in debates about race and racism. In fact the standardisation of technologies, such as a molecular clock, obscures not only the practices embodied in a technology itself but also the normative content of the objects enabled by it. And this is the very reason why stating that there is no such thing as race is not enough. For race is neither fact nor fiction, but rather a matter of doing.
Diversity: The Nice Thing About DNA Is That Everybody Has It

Story 3: talking back to Gender and Anti-racist Studies

The statement about DNA, namely that “the nice thing about it is that everybody has it” may bring about both egalitarianism and diversity: egalitarianism by making a universal claim about DNA - we are all equal because we all have DNA – and diversity in the sense of making everybody specific - we are all different in our DNA. Both readings, however, point to something essentially there, (in) the DNA. And that is not my purpose in using this statement. The reason I introduce it here is to argue that DNA is neither a commodity that can be appropriated or expropriated nor a fixed measure on which to base similarities and differences. Moreover I have introduced this statement to challenge a tendency within gender and anti-racist studies to side with “culture” rather than “nature.” An emphasis on genes and DNA is thus viewed with mistrust. Throughout this book I have argued that neither nature nor DNA are ever by themselves and I have shown that culture is part and parcel of genetic differences and similarities. Once more I want to knit the stories together and explore how we might think in a different way about the statement introduced above.

Egalitarianism and diversity are crucial categories in gender and anti-racist studies, as also in feminist and anti-racist movements. In brief one could say that the history of these academic fields and social movements has shown a change of focus during the last century, from a politics of egalitarianism to one of diversity. Demanding social equality between men and women and between the different “races,” albeit fruitful and important, also raised questions. Equal to what or to whom? Who or what is the universal standard of modernity and emancipation? And what about the differences between people’s lives and the appreciation of those differences? Ever since the late 1980s pluralism, multi-culturalism, and nowadays diversity have become the answer to bypass universal claims. Here I want to argue that neither egalitarianism nor diversity provide in themselves stable ground for feminist and anti-racist politics and I will consider what can be learned from my analyses of genetics, especially for a politics of diversity. Let us therefore turn to the narrative on diversity.

- Within gender studies it has been shown that the gender or man-woman category is discursive and heterogeneous. Ever since the nature-culture debates in the 1970s and the appreciation of the sex-gender distinction as such in the 1980s, however, little attention has been paid to “biological” sex. Differences between men and women were best understood as cultural, and gender became the field of studies, debates and
interventions. Some scholars have, however, suggested that the issue of "biological" sex is much too important to be left in the realm of scientific discourse only, and much too complex to be treated as a stable reference. They have put forward the argument that there is no reason to apply a special treatment of the biological as being different from the cultural, or to presume a given sex-gender distinction, even if the very distinction performs itself. Rather than what is essentially there in biology, the angle they suggest is an examination of practices in which sex materialises, is enacted and made to matter.

In this study I have investigated practices of sex difference in studies of genetic lineage. More specifically, I have compared two kinds of DNA research, one of which focuses on maternally inherited DNA (the mitochondrial DNA), and the other on paternally inherited DNA (the Y-chromosome). The leading questions in this comparison were: where can genetic sex be located? and how is it performed? To answer these questions a distinction was made between three different practices in studies of genetic lineage: the practice of genealogy, the practice of DNA and the practice of genetic lineage. These could cautiously be seen as the practice of theory, the practice of experiment, and the practice of analysis. Where sex difference is located and how the sexes were performed differed in a significant way between these practices. It was shown that in the practice of genealogy the sex of individuals is irrelevant to genetics, and that genetic sex is performed as a pattern of inheritance, i.e. whether a specific DNA fragment is passed on to the individual by the mother or the father. In a practice of DNA, genetic sex may be irrelevant altogether, such as in the case of mitochondrial DNA, because both males and females carry this type of DNA. But it may also be actively performed, as in Y-chromosomal DNA research. There the difference between males and females becomes important because, unlike males, females do not carry a Y-chromosome. However in such a practice geneticists were not so much interested in the individual as such but in collections of samples or of populations. They therefore aimed at studying the samples which were to hand and which work – given the availability of techniques and time. Hence, in the handling of DNA, genetic sex was not so much performed as a quality of a sampled individual but rather as that of an individual sample. In addition, in a DNA practice, sex difference was also enacted in various other ways. It may be performed as the spatial division between samples, as the information contained in forms about the samples or as repertoires from other practices that had entered the laboratory and had become part of the routine. Thus both during experiments and in theories about DNA inheritance sex was hardly ever performed as a quality of an individual. Rather sex difference materialised in various technologies of studying similarities and differences. Does this then mean that genetic sex is
never enacted as an individual quality? In my examination of the practice of genetic lineage, the practice in which the data is analysed and put in the context of population history, I have argued that the various different versions of the sexes that could be found in the laboratory were subsumed. In the cases of mitochondrial and Y-chromosomal DNA research it was shown that the data, put in the context of population history, were made to stand for women and men. One could say that in addition to the standardisation of DNA as a technology, the naturalisation of sex-difference also enables the naturalisation of population and differences between populations.

So what can be learned from this investigation? A focus on routine practices and on what scientists do showed how sex difference materialised in technologies, and that different versions of the sexes might circulate in laboratories. As well as sex difference in terms of man and woman, geneticists had many other technologies to hand in which it can be performed. Moreover the sexes might be performed and made relevant, but such was not always the case. And performing them, no matter how it was done, was temporary to the point of being unstable. Hence in laboratories genetic sex is not so much an essential quality of an individual but rather the effect of technologies and practices. However to state that technologies and practices are heterogeneous and that various different versions of the sexes can be found in laboratories is not to suggest that sex is a list of endless references to something essentially there in the DNA. Rather my analyses show that genetic sex itself is a matter of technology and that specific versions of the sexes can be performed in certain practices but not in others. This indicates that scientific practice itself questions the very distinction between sex and gender, opening the way to a rethinking of the natural and the cultural.

- In debates about race and racism the distinction between nature and culture took on an aspect different from that in the debates on sex and gender. As a way of coming to terms with racism after the Second World War, race was put on the agenda of a UNESCO meeting (December 1949), resulting in two statements. The first, presented mainly by sociologists, psychologists and cultural anthropologists, suggested that there was no scientific basis for human biological races and that race was being mistaken for population. The second, which was a consequence of geneticists’ and physical anthropologists’ discontent with the first, especially on the issue of presumed innate intelligence, turned the argument of scientific evidence around. The very lack of evidence was used to propose further research on race. A group of ninety-six scientists were consulted before the second statement was released, and a number of them suggested on-going studies and debates.
rather than a final consensus. Nevertheless as a spin-off to these debates population became the preferred category of biological research and race was confined to the realm of ideology and bad science.

As has been pointed out, the discourse of the Diversity Project is centred around "population." The brief post-war history of race suggests that there are stakes in studying practices of population. As was argued, population tends to be naturalised and practised as "race." But what impact do current technologies have on how race is performed and how is it done? Specifically, since population is an effect of technologies rather than something essentially in the DNA, and since it comes in various versions, the naturalisation of population suggests that something is also happening to race. The ever-growing number of genetic markers applied in the field of population genetics increases the ways in which population can be enacted. For example the boundary between one population and the other may be very different, depending on whether populations are studied on the basis of nuclear DNA or on mitochondrial DNA or whether the clustering is based on a small or a large number of genetic markers. This indicates that neither population nor race is pre-given, and suggests that race does not necessarily map on pre-existing biological classifications. This practice of race is not based on a pre-fixed category into which individuals are fitted. Rather it works the other way round. The starting point is an individual with an endless amount of genetic information through which race can be performed again and again as something different. One could say that, for better or worse, this side of the practice in new genetics is producing populations, races, and sexes in excess.

- Confining race to the realm of ideology and bad science has produced problems, and not only for scientists interested in biological classification, I would like to suggest. The treacherous, hotly-debated and slippery field of race also seems to have become a "no-go" area for scholars of science and technology, in view of the virtual absence of research on the materiality of race in techno-scientific practice. There might be various reasons for this, varying from simple lack of interest to problems of addressing the materiality of race without fixing it. Could it be that in addition to such reasons, the very absence of a nature-culture divide vis à vis race, like the one attributed to sex and gender, has contributed? Whereas the field of gender and technology has become established in STS, studies of race and technology are virtually absent. It seems that the impossibility of referring to race, just like sex, without referring to something fixed in "biology" has contributed to the omission. Gender appeared to be productive for those who wanted to avoid the materiality of biology; race, however, lacked such a cultural counterpart to
do a similar job. Race remained captive in the realm of scientific ideology. Rather than an issue of investigation it was treated as an issue of debate. In many cases it was the latter for very good reasons. However, as many feminist scholars have argued, the very distinction that confined sex to biology has led to problems in thinking the body and its materiality in technologies. Hence there is an urge to start to take race into account in studies of science and technologies and how it materialises in such practices. In addition there is an urge to remove race from the domain of taboo and deviancies in order to investigate how it is practised on a routine basis. For race does not only matter in terms of hierarchical distinctions, not only in terms of inferiority and superiority, but in many other ways. Among many others, race might “matter” as a difference between the isolated population and the genetic melting pot, or as a difference between what is genetically proximate or distant, or again in terms of geographical clusters of variability. In my studies I have focused on technologies of making such distinctions and traced how race is embodied in them. Taking routine practices into account it was shown that similarities and differences are neither vested messages in the DNA nor ideological additives of scientists. Rather racial distinctions materialised in technologies which, in the case of a reference sequence (Anderson), for example, were integral parts of both laboratory practice and the objects of genetics. This indicates that the materiality of race should not be located in the DNA or the body but rather in the technologies that help produce similarities and differences.

Hence neither race nor sex can ever be simply biology, nor simply ideology, just as they can never be simply nature or simply culture. They refer by “nature” to the socio-material density of that what we call biology. And here lies the point in stating that the “nice thing about DNA is that everybody has it.” What anybody may “have” is indeed a matter of practice and technologies. Now that biology has taken the shape of DNA, genes, and genomes, testifying to the contaminated object called nature-culture, race and sex force us to take account of how biology is done. But the stakes for feminist and anti-racist politics lie in denaturalising both DNA and technology simultaneously.

- Throughout this book I have traced the multiplicity of population, sex and race in genetic practices and have focused on the interdependence of technology and nature in such practices. My analyses centred around technologies, which enabled me to account for the fluidity of practices and the performed quality of objects. At various places I have suggested that the multiplicity in nature should not be taken for a list of references to something essentially there. This also has consequences for a politics of diversity.
Diversity has taken on a normative aspect in the last decade: it carries a positive meaning, so it seems. It does that in the very sense that it mobilises a critique of homogeneity or easy classifications (such as self and other, working class, middle class and upper class, man and woman, and the like). But it does not self-evidently prevent the foundational power of more refined categorisations. Indeed, it does not prevent such powers without the mediated and thus temporary nature of categories being in focus. Here lies the importance of what Donna Haraway calls embodied vision. Her metaphor of vision does not imply that seeing is directed by minds, nor does it suggest that some bodies are better equipped and generate better sight. Rather, the focus is on the dependent nature of both seeing and that which is seen. It aims at technologies in practices. Hence both viewer and viewed are effects of technologies located in time and space. From this we learn that there is no one stable ground, not even many, for opting for a politics of diversity or an egalitarian politics. Even if there might be still very good reasons, for specific people, in specific places and at specific moments in time, to choose either of the two. Thus introducing diversity into feminist and anti-racist politics does not, as such, yield better politics. It does not challenge the idea that there is an allegedly stable reference point for identifying similarities and differences. From practices of genetics we can learn that the ground for politics is crafted by technologies of similarities and differences. The core issue in such politics is: how are people performed as similar or different? Which technologies have pride of place in producing diversity? And to what effect? Meanwhile politics involves knowing that similarities and differences are neither the beginning nor the end, but that they are the fluid space of technology, blood and DNA in between.

Talking Forwards to Politics:

To conclude, let me return briefly to the Diversity Project and its mapping capacity. Making maps is making links. The spatiality of geography produced in maps transforms relations and determines what is near and what is far away on a map. Maps are therefore political objects, not only because of the boundary work they do but also because they produce visual centres and visual margins. A genetic map of the world embodies these politics as well. In the discourse of the Diversity Project, DNA is placed in the realm of nature. Among many other things, this discourse is about conserved genes and isolated populations versus mangled genes and the Western melting pot. Those who are not considered to be connected to the global traffic of humans and things, especially those in far-away places, carry DNA that is considered a source for understanding how the melting pot must have come about. This
is the kind of mapping that is familiar to us by the virtues and vices of history.

In this concluding chapter I have spent time mapping out the practices investigated in my study, and the different insights gained about genetic diversity. I have traced three narratives, three ways of talking about how to do politics with DNA. Talking about naturalisation I have argued that in genetic practice there is no such thing as a natural object: rather, the objects of genetics are enabled by technologies. However the naturalisation of technologies has the naturalisation of genetic objects as its effect. My point with naturalisation is that both objects and technologies appear autonomous and detached from the practices in which they are produced. Indeed naturalisation reifies the distance between the “isolates” out there and the “technology” here. Hence to do politics with DNA is to take into account the practices in which it is studied. In the narrative about standardisation the focus shifted from the how to the content of practices. My aim with this is that standards obscure the normative content they embody, and thereby obscure the normative content of objects enabled by them. Geneticists show special interest in differences in the DNA. However the process of standardisation makes inaccessible which technologies will be made into standards and, thereby, what kinds of practices are preferred for making differences. Genetic differences thus seem neutral and facts of nature. Obviously the politics of such differences is the real matter of concern in the Diversity Project. In my narrative of diversity I focused on sex and race and argued that similarities and differences are not inscribed in the DNA but in the technologies that help produce them. Addressing sexual and racial differences in genetics, I did not aim at unmasking geneticists as being sexists or racists. Rather my argument was that both sex and race are matters of routine technologies. Given its crucial role in the Diversity Project, I have specifically put forward the argument that race should be taken out of the realm of ideology and deviancy, and that further investigation is needed to learn more about how it is practised in scientific routines. For taking account of routines of making similarities and differences and the normativities they involve may sensitise STS scholars, geneticists, as well as gender and anti-racist scholars to the kinds of links and lineages which go to constitute the map of the Diversity Project.
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Notes to Chapter 6

2. Questioning the ontological difference between micro and macro, or local and global phenomena or mechanisms, is in fact one of the major achievements of the Actor Network Theory, see for example John Law and John Hassard, eds., *Actor Network Theory and After* (Oxford: Blackwell Publisher, 1999). For an elegant elaboration on the relation between the local and the global, and how the local and the global together localise, i.e. specify, the limits of a field, see Marilyn Strathern, “The Nice thing about Culture is that Everybody has it,” in *Shifting Contexts: Transformations in Anthropological Knowledge*, ed. Marilyn Strathern (London, New York: Routledge, 1995), 153-177, p. 167.
3. Although not very satisfied about it himself, John Law has termed this kind of work: a kind of juggling while trying to keep all the balls in the air, John Law, *Organizing Modernity* (Oxford, Cambridge: Blackwell, 1994), p. 188.
6. This phenomenon may be particular or exceptional within the field of technology studies. In genetics however, and maybe in various other branches of the life sciences, it is rather the rule than the exception. For the same can be claimed for various other kinds of objects or technologies, see Hans-Jörg Rheinberger, “Von der Zelle zum Gen: Repräsentationen der Molekularbiologie,” in *Räume des Wissens: Representation, Codierung, Spur*, ed. Hans-Jörg Reinberger, Michael Hagner, and Betina Wahring-Schmidt (Berlin: Akademie Verlag, 1997), 265-279.


9. I wish to emphasise that this is a common notion within STS. It might seem to contradict ideas of Bruno Latour about scientific facts and their future users. However in the citation above he is making a different argument, namely that scientific facts can never be end products.

10. The first conference was “The International Planning Workshop,” held in Porto Conto, Sardinia in September 1993, the second “Human Genome Variation in Europe: DNA Markers,” which took place in Barcelona, Spain in November 1995.


12. After I had finished my research I worked in a laboratory where such kits were validated and optimised for routine use. For some of the technicians it was a kind of “sport” to experiment with the kits mainly by diluting the reagents, aiming at finding their breaking point.


15. At this point it serves well to repeat a quotation (from the introductory chapter) about the contribution aimed at by the Diversity Project vis à vis race. Diversity research will be “leading to a greater understanding of the nature of differences between individuals and between human populations, [...] and will make a significant contribution to the elimination of racism”(HUGO, “Human Genome Diversity (HGD) Project: Summary Document,” [Sardinia: 1993], p. 1).

16. See, for example, Cory Hayden, Joan Fujimura who argue that genetics never served as a means to fight against racism and who take the statement about race to be merely rhetoric by the Diversity Project, Corinne Hayden, “Patently Natural: The Culture of Genealogy and the Nature of Biodiversity,” (Santa Cruz: University of California, 1995), 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).

To state that genetics never served as a means to fight against racism, however, would underestimate the impact and the effect of - for example - the UNESCO Statement on Race, or that of the mitochondrial DNA theory of Alan Wilson (the so-called Out of Africa Theory). Both Wilson’s theory of common origin and the UNESCO Statement of the have contributed to broad debates about race and scientific racism. On the lived-in reality of race and racism, see Malcolm Cross and Michael Keith, eds., Racism, the City, and the State (New York, London: Routledge, 1993), see especially Susan J. Smith, “Residential Segregation and the Politics of Racialization,” in Cross and Keith, Racism, the City and the State, pp.128-143.

17. This heading is borrowed and modified from Strathern, “The Nice thing about Culture” (above, n. 2).


19. Expressing the wish to focus more on diversity, this change has been expressed in the name of the Centre For Gender and Diversity at the Maastricht university.


21. Moreover Donna Haraway, Annemarie Mol as well as Judith Butler have argued that in a 'colonising move' the cultural of gender has become parasitic of the biological/material of sex. They plead for a refiguration (Haraway) of the materiality of sex. See, Donna J. Haraway, Modest Witness


22. See especially Hirschauer and Mol, "Moving Stories" (above, n. 21), see also Judith Butler, Gender Trouble (above, n. 21), chapter 1.


24. UNESCO, UNESCO and its Programme III: The Race Question (Paris: UNESCO Publication 785, 1951). The issue of debate in this document was not so much physiological differences between races/populations: rather it aimed at questioning the distribution of presumed innate intelligence according to biologically defined clusters of people.


28. For the kind of troubles produced for scientists, see Donna Haraway, Modest_Witness (above, n. 21), p. 239; idem, Primate Vision (above, n. 26), pp. 197-203.


31. This does not mean however, that cultural arguments have not been embraced in racist politics and that cultural differences were not essentialised. For examples of how this has been done in recent British politics, see Martin Barker, The New Racism (London: Junction Books, 1982), see also Mol, “Wombs, Pigmentation, and Pyramids” (above, n. 21). Similarly gender differences were at places essentialised by feminist scholars, see for various examples Haraway, “Gender for a Marxist Dictionary” (above, n. 20).
33. For this argument, see Barker, The New Racism (above, n. 31), Mol, “Wombs, Pigmentation, and Pyramids”(above, n. 21).
34. I am aware that I am neglecting the possessive claim in the term “having”. But let me state this. “To have” based on the possessive right in the self that C.B. Macpherson has wonderfully discerned in western modernity, enables the agency of the subject. The question is, however, where to locate the action? Now that the subject has been decentred, agency goes well beyond the power of those who have by “nature” or law, and well beyond the intentionality of delegation. Macpherson describes liberal-democratic theory as follows: “Its possessive quality is found in its conception of the individual as essentially the proprietor of his own person or capacities, owing nothing to society for them” (C. B. Macpherson, The Political Theory of Possessive Individualism: Hobbes to Locke [Oxford, New York: Oxford University Press, 1990[1962]], p. 3). The redistribution of power as in the case of DNA leaves little to the expectation and may well question our very concept of possession in capitalist societies. On the latter, see Karl Marx, Das Kapital: Kritik der politischen Ökonomie (Berlin: Dietz Verlag, 1974 [1890]).
35. See for a critique of diversity, Hayden, “Patently Natural” (above, n. 16).