A Postgenomic Perspective on Sex and Gender

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Abstract

Gender is a concept that has major implications for many areas of philosophy. It is a concept that clearly has a close connection with sex, a topic that has been studied intensively by biologists. The nature of sex, and its relation to gender are thus questions that fall centrally within the remit of biophilosophy. Both sex and gender, I argue, should be understood as the outcomes of developmental processes more or less stabilised by a wide variety of more or less variable factors. Understanding the nature of these processes and their social and biological causes is essential for comprehending the nature of gender, its relation to sex, and the extent to which these are mutable.

Introduction

Gender is the central concept of a thriving and diverse area of philosophy. The different roles, rights, responsibilities, and so on allocated to men and women by

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various societies raise basic questions for ethics and political philosophy. Assumptions about these differences have been argued to have important influences on metaphysics, epistemology, science, and more. Such topics are loosely encompassed within feminist philosophy, though of course this is not an isolated domain of inquiry, but one that claims major relevance to all the fields just mentioned. Sex plays an obvious role in all this: differential roles in reproduction are typically central to the justification of the differences in male and female social roles that are called in question by feminists generally and feminist philosophers in particular. This, however, is a matter of what might be called surface sexual difference. A central thesis of "second wave" feminists of the 1960s and beyond was that the differentiated social roles and statuses of men and women were contingent and mutable. Different societies, and societies at different times, articulated gender in quite different ways. Surface sex, a set of generally easily accessible biological differences, was the basis on which gender roles were assigned, but these roles were in no way determined by sex. This view specifically opposed a longstanding and continuing tradition that claims that much of gender difference is natural, growing inevitably out of underlying sexual difference. Gender, on this latter view, is seen as an expression of non-obvious ('deep') sexual difference.

Half a century ago feminist scholars worked hard to establish this distinction between sex and gender, precisely to distinguish the biological differences between men and women (sex) from the cultural differences that many assumed were just as much a part of nature (e.g. Rubin 1975; Unger 1979; Fausto-Sterling 1985. The distinction was introduced by Stoller 1968). From the beginning, however, the distinction has been controversial, even among feminists; prominent recent critics have included, for example, Judith Butler (1990). The central concern has been that the distinction tends to reify gender as something as real as, but just different from, sex. Not only does the concept of gender threaten to occlude the importance of interactions between gender and race, ethnicity, class and other important social divisions, but more generally it obscures the uniqueness and diversity of individual women[2]. As will become clear by the end of this paper, I am sympathetic to these concerns about gender. But the concept does remain valuable at least for analysing biological accounts of the development of human differences, specifically, as is my aim in this paper, for assessing the interaction between internal and external influences in the development of human differences. If in the end the intricacy of interaction between biology and culture is so great that the distinction between sex and gender can be shown to have no ultimate ontological import, it may be best seen as a ladder that we have climbed and are now in a position to kick away. But if so, we should be very clear why we are doing so.

The sex/gender distinction is, at first pass anyhow, intuitively clear. Sex is a biological distinction grounded in reproductive physiology. Most people—though the word 'most' is very important—have a reproductive physiology and, later on, secondary sexual characteristics such as breasts or facial hair, that clearly distinguish them as male or female. Gender, on the other hand, refers to

[2] A classic example of such criticism was the response to Betty Friedan's classic, The Feminist Mystique (1963), often credited with launching the second wave of feminism. Critics objected that Friedan, in objecting to the confinement of women to the domestic sphere, was essentialising the experience of middle-class white women while failing to notice that poor women (disproportionately minorities) were already in work, often in the homes of middle-class white women and enabling them to pursue non-domestic careers (hooks, 1984).

behaviour that is characteristic of members of one sex or the other in a particular society. In most societies men and women wear different clothes; but not in all societies, and not the same clothes wherever they are differentiated. This is an aspect of gender. The most important aspect of gender is where it interacts with the division of labour. All societies allocate different tasks to different people, and thinkers such as Adam Smith have made a compelling case that this division of labour is the foundation of the economic success of human societies. In all or almost all societies this division is more or less gendered. Some work is considered appropriate for men, some for women. An array of differences in status, pay, responsibility and much else follows from these differences in allocation of work.

My aim in this paper is not, however, to contribute to the extensive and important body of work that has explored the social and political ramifications of gender difference. Rather it is to look at the biological and ultimately ontological foundations of the sex/gender distinction. This is where the biophilosophy that is the focus of this volume has an important part to play. For while public debate continues as to whether gender is ultimately an expression of deep sex, or rather, as feminists have assumed, a politically mutable feature of the organisation of society, this should no longer be an issue in light of advances in biology over the last half century. The biological determinism of the former perspective is no longer scientifically defensible. The reasons for this, and the exploration of its implications for philosophical understanding of the human and the social offers a paradigm for what I take to be the role of biophilosophy. And nowhere are these implications more telling than for the understanding of sex and gender.

Essentialism

Sex and gender have often been understood in terms of essences. Essentialism is a doctrine both about language and about the world. We cannot speak without dividing the world into kinds. When I tell you the cat is on the mat, I convey information by distinguishing the thing on the mat from all the countless kinds of animals and for that matter non-animals that might have been there, and I distinguish the thing it is on from all the rugs, carpets, rocks, logs, and so on that the cat might have been on, but isn't. But what, philosophers have asked since antiquity, makes something a member of the cat kind rather than the dog kind, the badger kind, etc.? Does the world in some way divide things up for us, and do our words register these naturally given divisions? Essentialism answers both these questions in the affirmative[3] . And if this is right, the question for the philosopher, or the scientist, is to discover what are the real divisions determined by Nature[4].

Classic versions of essentialism deriving from the ancients were famously criticised by John Locke. Like other contributors to the Scientific Revolution of his time, Locke thought of the natural world as ultimately composed of nothing but atoms moving in the void. If things had essences, they must be determined by the structure and relations of these atomic parts. But since, as he famously

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[3]An influential contemporary version of essentialism holds that real kinds are demarcated by essences, but that only physics and chemistry are likely to contain real kinds (Ellis 2001). In some respects this view is congenial to the anti-essentialism that I shall defend, but only because of the explicit denial that essentialism has immediate relevance to the kinds of kinds with which I am concerned.

[4]For more detail on these issues, see Bird and Tobin (2012).

remarked, we lack microscopical eyes, such essences were inescapably beyond our reach, and there was no reason to believe that the ways we divide up the world at our own gross macroscopic level correspond to any reality at the microscopic level. However, many have concluded that Locke's pessimism was premature. We may still lack microscopical eyes, but we do have electron microscopes, high throughput gene sequencers, and even atomic tweezers. So our ability to correlate the observable world with an underlying reality is very considerable and growing. Essences, it appears, are back within our grasp. Every day the complete genome sequences of more organisms are announced. Are these perhaps contributions to a growing library of essences?

Biology at a less rarified level has been a fertile breeding ground for essentialism. Anyone who enjoys the outdoors is likely to be struck by the distinct kinds of organisms that are encountered in the wild. There are foxes and rabbits, dandelions and oak trees; one rabbit is pretty much like another, very different from a fox, and there are no intermediate hard cases. Yet a wider spatial view and, especially, reflection on evolutionary history tell us that if we look a little further in time or space there are always intermediates and always hard cases. Not so many million years ago there was a common ancestor of the fox and the rabbit. If we could go back in time observing all the ancestors of the rabbit until we reached that common ancestor, and then forwards again through the ancestors leading up to the fox, we would have a more or less smooth series of intermediates leading between these two so very different animals. With a lot more time we could do the same thing for ourselves and a mushroom.

A similar point can be made with respect to space. A striking example is provided by ring species. Where I write, in the United Kingdom, the herring gull (*Larus argentatus argenteus*) and the lesser black-backed gull (*L. fuscus*) are two very familiar and quite distinct species, not known to interbreed. Yet it appears that if we track round the globe at roughly the same latitude there exists a series of gradually diverging species each member of which is capable of interbreeding with the next, but at the end of which are the herring gull and the lesser black-backed gulls. Here we find exactly the phenomenon just described in a temporal context recapitulated in space.[5] In biology, it appears, distinct kinds are not given to us by nature, but rather by our local and limited perspective on nature. So, to return to the main topic, our natural intuition that men and women are essentially different kinds distinguished by distinct inner natures should be treated with caution. We should at least look very carefully at what exactly the differences—and similarities—really are.

From Essence to Process

Let me turn, then, to the broadest of the categories relevant to the present topic, male and female. It is easy to imagine that these are biological universals, fundamental to the reproduction of living beings. Nothing could be further from the truth. The vast majority of organisms do not have sexes at all. This includes the single-celled organisms that constituted the living world for 80% of its history and remain by far the most common organisms, but also many so-called

[5] This classic example has recently been called into question and it has been suggested that the relations in question are considerably more complex (Liebers et al. 2004). This does not affect the general point, that populations of organisms exhibit gradual change over space, and that terminal members of such graded populations, or clines, may be very different from one another.

‘higher’ animals and plants. Many plants, though they engage occasionally in sexual reproduction, generally reproduce asexually. And many organisms have more than two sexes, or breeding types[6].

Even among organisms that reproduce only sexually, and that have only two sexes, sex can be fluid. Many reptiles become male or female in response to environmental conditions such as the temperature at which their eggs incubate. Some fish change their sex in midlife: as the position of dominant male becomes vacant in a group of Bluehead Wrasse (*Thalassoma bifasciatum*), the largest female turns into a male. These examples bring me to the main biological idea underlying this discussion. Organisms in general, and sex in particular, must be understood developmentally[7]. And development, at least for complex multicellular organisms, is not something predetermined ‘in the genes’ but a process of interaction between the developing organism and its environment[8].

A philosophical corollary of the above thought is the following: organisms are not things, but processes. This is an ancient distinction, often associated with the famous remark attributed to the Greek philosopher Heraclitus, “No man ever steps in the same river twice, for it's not the same river and he's not the same man.[9]” The only constant, for Heraclitus, was change. Modern opinion has tended

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[6] Nanney (1980) describes a protozoon in which seven distinct mating types can be distinguished.

[7] Rather wonderfully, the Bluehead Wrasse just mentioned also illustrates this idea in a quite different way: young Blueheads, but not older fish, will often serve (work?) as cleaner fish.

[8] Detailed defence of this assertion is well beyond the scope of this article. For extensive biological details of the developmental interaction between organism and environment, see Gilbert and Epel (2009). For philosophical discussion of modern understandings of genes and genomes, see Griffiths and Stotz (2013).

[9] I must admit that this famous quote is in fact a bit problematic. For, of course if a man and a river are processes then the man and the river may well be the same processes at different times.

to embrace the alternative opinion of Democritus, that ultimately there was nothing but atoms—unchanging things—in the void. Indeed a version of atomism was a central plank of the scientific revolution of the sixteenth and seventeenth centuries in the West, and has tended to remain a default assumption of most thinking about science (except, perhaps, for the last hundred years, by physicists). But this view, understanding the world as ultimately composed of unchanging things, has not served biology well. A process, unlike a thing, is maintained by change. A chair can sit in the attic for decades doing nothing, but still remain the very same chair. Organisms, by contrast, maintain themselves by doing all kinds of things—metabolism, cell-division, and so on. An animal that does nothing is a dead animal. The integrity of a process is maintained not by the constancy of its temporary parts, but by their causal connections. Our paradigm of a human tends to be of an average age adult; but that is no better or worse than thinking of a child or, for that matter, a fetus or an old lady. Biologically, what is fundamental is a life cycle: what makes parts of a life cycle stages of the same life cycle is not having the same properties at different times, but relations, of continuity and causality between stages. The whole need not be held together by constant, still less essential, properties.

Sexual Differentiation

So let us now look at the processes through which differentiated sexes in humans develop[10]. Whereas we tend to analyse a thing into its parts, a process is

[10] This paper, and especially the present section, is deeply indebted to the work of biologist and gender theorist Anne Fausto-Sterling. Her *Myths of Gender* (1985) pioneered biologically informed criticism of purportedly scientific accounts of gender difference, a project developed in

naturally analysed into stages. Needless to say, perhaps, in neither case can we assume that the divisions are clear or unambiguous. However, the following provides a sufficiently clear series of stages for present purposes.

1. *Chromosomal sex*. Most women have two X chromosomes, and most men have an X and a Y chromosome; and they originated from a fertilised egg with those chromosomes. The word 'most' is very important, however. First, not all humans have either an XX or an XY genotype. There are people with XYY, XXY and XO chromosomes (or karyotypes), of which the first are generally assigned a male gender, and the last two are generally treated as female. Second, for various reasons, including now elective reassignment, later stages in gender development do not always coincide with chromosomal sex.
2. *Fetal gonadal sex*. By 12 weeks most foetuses have embryonic gonads, irreversibly committed to becoming either testes or ovaries. The development of testes appears to be triggered by a gene on the Y chromosome the product of which binds to a gene on chromosome 17, and triggers a cascade of events involved in the production of the testes. A different sequence of genetic events pushes the as yet undifferentiated gonad in the direction of becoming an ovary. The Y chromosome gene just mentioned is known as the Sry gene, which stands for Sex Reversal on the Y chromosome, echoing the curious idea, dating from Aristotle, that being female is a default. The persistence and untenability of this idea is noted

new directions in *Sexing the Body* (2000). The outline of the stages of sexual differentiation here closely follows her *Sex/Gender* (2012).

by two experts on the relevant genetics: “The discovery that gonads develop as ovaries in the absence of the Y-chromosome (or, more specifically, the Sry gene) supported the prevailing view that the testis pathway is the active pathway in gonad development. However, as Eicher and others have emphasized, the ovarian pathway must also be an active genetic pathway” (Brennan and Capel 2004, citing Eicher and Washburn 1986.) Of course, if the Sry gene is indeed the relevant ‘switch’ it might equally well be described as preventing ovary development. In neither case is the ensuing genetic cascade fully understood.

3. *Fetal hormonal sex*. As the gonads develop they begin to produce their characteristic mix of hormones. The reproductive system, under the influence of these hormones, begins to differentiate towards characteristically male or female physiologies. Again, this depends not only on the production of hormones, but also on the proper functioning of receptors that recognise these hormones. So, for example, occasionally XY foetuses carry a mutation that hinders androgen recognition, and produces children born with highly feminised external genitalia. If everything follows the standard path, however, this leads us, finally, to
4. Genital sex, the standard criteria that are used to distinguish the sex of babies at birth.

The process of foetal differentiation, then, is complex and multifactorial. While most babies will be born either with an XY genotype and typical male physiology, or with an XX genotype and female physiology, there are many ways in which these typical outcomes can be derailed. It is no surprise that there are a significant number of atypical outcomes, sometimes described as intersexed, now more often said to exhibit 'Disorders of Sex Development'; though one may wonder whether describing atypical development as disordered constitutes progress.

The next crucial point in human development is, of course, birth. This is the point at which the wider community decides whether a baby is a boy or a girl. In the cases where this decision is difficult, standard medical practice has been to attempt to adjust the baby to one or other of the standard kinds. This often involves surgical reshaping of the external genitalia and treatment with hormones. The *exhaustive* division of people into two sexes is not a reflection of how things are in the world but of a social policy that everyone must be assigned to one or other of these categories. Very recently some countries, including Germany, Australia and New Zealand have allowed babies to be registered at birth as of indeterminate sex, though this move is highly controversial, and has been criticised by some advocates for intersex people as maintaining a fixed and determinate set of categories.

Gender Differentiation

Though techniques of foetal surveillance such as ultrasound may rapidly be changing this, to a rough approximation gender begins at birth[11]. And the

[11] From the point of view of development we should not, with due consideration to its significance and sometimes traumatic nature for the mother, see birth as a

countless institutions that enforce gender require that it be decided on which side of this fundamental dichotomy every individual falls. On endless forms we must say whether we are male or female—a question generally framed as a request for our sex, though more accurately it should ask for our gender. As noted above, however, in some places this dichotomy is being challenged, and the effects of this on the gendered organisation of social life are as yet impossible to predict.

At any rate, development moves on. For most of us this continues to follow physiologically one of two fairly well-distinguished paths of sexual differentiation, though with wide variations in detail, and with a few more along the way joining the ranks of those whose sexual development differs substantially from either norm. While the typical differences radiate out into many other parts of physiology, the further these are from the core reproductive systems, the less this difference will be sharply dichotomous, and the more it will become statistical and overlapping. The average upper body strength of men, for instance, is greater than that of women, but there are many women with greater strength than many men.

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cataclysmic turning point. The baby is little more independent from the mother, for instance, than it was before birth, though it may derive its nutrition from a different part of her anatomy. (Though certainly being born is traumatic and a serious struggle from the baby's point of view, and the world is a very different place from the uterus. Thanks to Juliet Mitchell for reminding me of this!).

Of central importance in our species, social and psychological development also takes off, with an enormous range of external factors impinging on the developmental process, many of which are relevant to the continuing bifurcation of the population into the socially condoned male and female kinds. Boys and girls are differentially hugged, given dolls or guns, pink toys or blue toys, and taught the intricacies of the gendered division of people. By three children more-or-less well know that they are boys and girls, and know many of the behaviours, likes and dislikes that are expected of them as such. These systematic differences in behaviour are elaborated in distinctive ways through the life cycle. Most men and women continue to dress differently; to choose different leisure activities; and, most importantly, to do different kinds of work, both in the labour market and in the home. The nature of these differentiated pathways has certainly changed over time, though not always in the ways feminist activists have hoped. As is often observed, increasing participation by women in the labour market has tended to be concentrated in less well-paid employment, and when the same employment, pay for women is still always lower; increased male participation in domestic work has not been commensurate.

Explaining Gender Difference

There are certain purported explanations of gender difference that have particularly attracted scientific attention. One of these has been the exploration of differences in male and female brains, a tradition that goes back at least to the nineteenth century (Cahill 2006; for penetrating criticism, see Fine 2010). Since, it is often said, brains cause behaviour, such research is often seen as a search for a fundamental cause of behavioural difference. An even more fundamental cause may then be sought in the genes if, as many also suppose, genes explain the properties of brains.

In parallel with the investigation of genetic and neurological differences between men and women has been the search for evolutionary explanations of gender difference. Here attention has focused on realms of behaviour that are seen to be especially significant for evolutionary success, most notably mate choice and parental investment (Buss 1999). The familiar cental argument is that since women invest far more in a pregnancy than men—eggs are bigger than sperms, and gestation takes a lot longer than copulation—they will be more concerned to optimise the chances of success for any reproductive endeavour. This is taken to imply that women will have evolved to be very careful whom they mate with, looking at least for the best genes on offer, and if possible for a little help in rearing the offspring. Men on the other hand, need only make a minimal investment. The evolutionarily rational strategy is to fertilise as many women as possible and trust that some offspring will make it to maturity. As sociobiologists like to remind us, the potential reproductive success of a male is almost limitless. It is said that 10% of the male inhabitants of what was once the Mongol Empire are descended directly from Genghis Khan, approximately 16 million individuals or one man in 200 in the entire human population (Zerjal et al. 2003).

These differences in reproductive strategy are the starting point for evolutionary speculation, but their implications are seen to ramify far more widely. It is natural for women to monopolise childcare and domestic work, given their evolved concern to invest in their children; inevitably they have less time for the outside world of work. Perhaps the need to compete with other men in the labour market—and ultimately thereby for access to women—will require cognitive capacities unnecessary in the differently demanding home environment. At least, evolved cognitive capacities are likely to be different.

These stories fit together into a broader picture that understands gender difference—or here we might as well just say sex difference—in an impressively integrated way. Natural selection placed different pressures on our male and female ancestors; these resulted in the selection of different genes, which are expressed in different brain structures; different brains cause different behaviour. Let us call this the Biological Big Picture.

I think almost everything is wrong with the Biological Big Picture (for more details see Dupré 2001, and Dupré 2012, esp. Ch. 14). Here, however, I will concentrate on one set of pivotal players in the story, genes. Genes, in the Big Picture, cause organisms to have particular properties, in this case properties of their brains that make them, for instance, keen on spreading their seed as widely as possible. Such properties make the individuals that exhibited them evolutionarily successful, and the genes that cause them are selected. But can genes really do this job?

Genes and Genomes

The science of genetics took off in the early twentieth century with the work of Thomas Hunt Morgan and collaborators on the fruit-fly, *Drosophila* (Kohler 1994). This work was the study of the inheritance of difference. Some flies have red eyes, some white. When a red-eyed fly mated with a white-eyed fly, or another red-eyed fly, what proportion of the offspring had red or white eyes? Morgan and colleagues bred and counted many thousands of flies and their differentiating traits, and the results of this work were interpreted in terms of the seminal insight that an individual had two sets of genes, one from each parent who, in turn, contributed half their genes to each offspring. Entities such as genes for red or white eyes were thus inherited from parents, and these interacted in specific ways. For example, the red-eye gene is said to be dominant, as a fly with a red-eye gene from one parent and a white-eye gene from the other will have red eyes. This kind of work, describing the transmission of genes bearing specific traits, is often referred to as Mendelian genetics, honouring Gregor Mendel's pioneering work on peas 50 years earlier.

Morgan's work made fundamental contributions to the advance of genetics, and Mendelian genetics still play an important role in areas of medicine and agriculture. But Mendelian genetics is now a very small part of genetics, or as some prefer now to say genomics. This is because Mendelian genes turn out to be a very minor part of genomes (Barnes and Dupré 2008). Most genes[12] cannot be correlated with a particular feature of the organism. Those that can are generally defects that make a gene non-functional. Consider the familiar

[12] I'll assume, for the sake of argument, that it's even useful to think of genomes as divided into genes. This assumption, however, is increasingly debatable (see Barnes and Dupré 2008; Griffiths and Stotz 2013).

example from human genetics, blue eyes. Blue eyes reflect the failure to make melanin in the iris. One functioning gene will suffice to produce melanin, so the brown gene is dominant. The blue eye gene is not really a gene to make blue eyes, but a defect in the gene that makes eyes brown[13]. And of course single gene diseases such as cystic fibrosis, or Huntington's disease, to which Mendelian models still apply, are unsurprisingly caused by dysfunctional genes.

What Mendelian genetics most crucially leaves out is *process*. While no one doubts that there is a process that leads from the zygote or embryo to the adult, talk of genes for this or that trait allows us to ignore it, and thereby allows us to ignore all the further factors that are necessary for this process to occur and all the different outcomes that interactions with these factors may make possible. This omission meshes with a related perspective on evolution[14]. Natural selection it is sometimes said, cares only about the outcome and if a gene for outcome X is selected, then somehow or other outcome X will appear at the proper time. Development—the process—can be blackboxed. We know what goes in and we know what comes out. We don't need to worry about what happens inside the box.

One might have supposed that this lacuna would have been filled with the development of molecular genetics that followed the iconic discovery by Crick and Watson[15] of the structure of DNA, by then recognised as the genetic material. But in fact, though this did lead to the discovery of some fundamental processes,

[13] . Eye colour, like most relations between genotype and phenotype, is really much more complicated, but the simple story will serve for present purposes.
[14] A perspective best known in the work of Richard Dawkins (1976).
[15] And Maurice Wilkins and Rosalind Franklin.

notably the way in which sequences of nucleotides, constituents of DNA molecules, could determine the production of particular proteins, the main functional molecules in living systems, processes of development were still not closely integrated into genetics.

One reason for this was that many geneticists continued to think (or anyhow speak) in terms of genes for this or that feature of the phenotype. Of course, they were well aware that when one spoke of a gene for high intelligence, or a gene for homosexuality, this did not provide the whole causal story. Many other genes—and much else besides—would be involved in the pathway from the gene to the trait it helps to cause. However, the genome as a whole was still seen as providing the complete code, recipe, or blueprint for the organism. The recipe was susceptible to minor changes, no doubt, as witnessed by the variability observable in actual individuals. The variations could be understood in terms of Mendelian genes that caused molecular differences, which in turn changed the probabilities of particular outcomes. Both the standard pattern and the variations from the pattern could be seen as determined by the genes, and there was no pressing need to take the developmental processes out of their black boxes.

Within this framework, sex determination was a paradigmatic Mendelian system in which, perhaps unsurprisingly, the Y chromosome was dominant. Being female resulted from having two copies of the recessive X gene[16]. As with other

[16] An important anomaly in the system is that only XX and XY pairs are capable of mating. This curious feature underlies Fisher's (1930) famous argument for why, under most circumstances, XX and XY genotypes will be equally common.

Mendelian systems, the differences between individuals, the XX and XY 'phenotypes', were taken to be both explained and caused by the genetic differences.

Counterposing this model with the complexity of the process of sexual determination sketched above begins to reveal the problems with the blackboxing strategy. Though there are typical developmental trajectories for embryos with XX and XY chromosomes, there are many ways in which individual developmental histories can diverge from this. Other genes, such as the binding site for the transcript of the Sry gene, determine whether the Y chromosome has its typical effect. And, as will be explained below, the activity of genes is frequently influenced by environmental factors. A strict and exhaustive dichotomy of outcomes is enforced at birth rather than supplied by Nature.

The development of gender differences after birth may seem closely parallel to the development of sex differences: there are two standard, typical, developmental trajectories. While there are anomalies—tomboys, transvestites, homosexuals, etc.—there is a typical path of development towards, let us say, heterosexual, promiscuously inclined men, competing with one another in various workplaces and marketplaces, and heterosexual, preferentially monogamous women, gossiping pleasantly with one another while taking care of the children and the home. These are the stereotypes implied by popular models of the evolutionary elaboration of sex roles in reproduction. It is admitted that many contemporary societies have moved some distance from these stereotypes, opening the workplace to women and domestic labour to men, and are increasingly tolerant of those outside the main pathways of gender normality. But this, it is often added, is always with some difficulty, requiring a battle against the tendencies laid down by Nature. We can try and get more women to be physicists, or philosophers, or men to do the housework, but we are fighting against their intrinsic nature. Nature, here, is the innate tendencies of the genes, as selected by millions of years of evolution[17].

But nature, or genes, do not work like this. There are no genes dedicated to heterosexuality, the love of big machines, or good housekeeping that need to be diverted from their natural trajectories. There is a genome that, given a specific sequence of surrounding circumstances, and subject to a certain amount of unpredictable noise, produces an adult individual with certain characteristics and dispositions. Change the environment, and you may very well change the outcome.

So what is a genome? We often think of genomes as sequences of letters, C, G, A and T, that form a code; and sequence can be a very useful thing to know about a genome. Technologies from molecular phylogeny, the genetic exploration of evolutionary relations, to forensic genomics, the identification of criminals by the material they leave at crime sites, depend on the comparison of genome sequences. But there is a great deal more to a genome than its sequence.

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[17] In their more general theoretical statements evolutionary psychologists are usually careful to distance themselves from genetic determinism, and note that actual outcomes depend on a range of environmental inputs. This then raises a problem in how to understand their more empirical work aimed at demonstrating that the phenotypes predicted by evolutionary speculation are indeed found in human populations. These phenotypes must at least be understood as typical or default developmental outcomes, even if environmental accidents sometimes derail them from this default tendency.

Considering that the chromosomes in a human cell measure about 2 metres, and the diameter of a cell is of the order of 100 micrometres, there is an obvious question of how the genome can be made to fit. In fact it is not just stuffed in any old how, but exquisitely coiled and folded. Moreover, the details of this folding, or condensation, are crucial to what the genome does. To put it simply, to be expressed, a gene or a section of the genome must be accessible to the transcription machinery; and condensation implies that most of it is not accessible. The shape of the genome changes constantly, and so does, partly in consequence, its activity. And these changes are brought about by other molecules in the cell responding to many features of the wider system and even environmental influences far beyond. The study of these changes is part of the science of epigenetics, the exploration of chemical and physical changes to the genes or the genome, how they occur in response to a wide range of external causes, and what are their effects. Paradigmatic and detailed work here is on the development of behavioural dispositions in rodents (Champagne and Meaney 2006; Champagne et al. 2006); but there is also a growing body of research on the way human physiology or psychology responds to developmental influences in ways that are mediated by changes to the genome[18].

The crucial point is this. We have been encouraged to think of the genome as something static and fixed, a programme or recipe that guides or directs the development of the organism. This is quite wrong. It is important that gene sequence is very stable, as the genome is indeed a repository of information

[18] For an overview of the significance of recent advances in epigenetics, see Meloni and Testa (2014)

about possible protein structures. But the genome does not itself say what is to be done with that information. The application of genomic information occurs as part of a process in which the genome is a dynamic participant, and which is highly sensitive to a range of external influences.

Back to Gender

So what does all this tell us about gender? Gender is a bifurcated developmental process that tends to lead to two distinct suites of characteristics that are mapped on to the typical physiological states male and female. These processes are not inscribed in the genes: nothing is; they result from an array of molecular, physiological and environmental factors coordinated reliably to produce certain typical outcomes. The fact that they are not written in the DNA does not mean that we can change them at will. Developmental processes tend to be very stable for good and obvious reasons. Indeed life would be impossible if there were not developmental processes that fairly reliably reproduced in offspring the characteristics of parents. Parents not only provide genomes, they provide for their offspring the sequence of environments that channel development in the typical direction. This may be no more than providing exactly the right place to deposit an egg, or it may involve creating a complex built environment such as a bird's nest, a beaver's dam, or a termite mound[19]. It will often also involve imparting behaviour through imitation or other kinds of training; and the

[19] For the importance to evolution of so-called niche construction, of which such environmental modifications are examples, see Odling-Smee, Laland and Feldman (2003). The central role of this process in human evolution and development should be self-evident.

training imparted will typically be that to which the parent, in its development, was exposed.

Humans have taken the complexity of these developmental processes far beyond anything else in the natural world. The environments in which we place our children have reached a bewildering complexity, parenting is an often frighteningly difficult skill, and socially provided institutions from maternity wards to universities are designed to contribute to the development of our offspring. Because so much of the developmental matrix in which humans grow is constructed by us, it follows that we have unparalleled abilities to change the developmental trajectories of our children. I do not say that it is simple to change these institutions, still less that it is easy to tell what will be the consequences of changes that we make; but I do say that it is possible. Feminist scholars have for decades been pointing to the variety of gender systems found in different places and at different times, and inferred that the presence of a particular system is always contingent. Their critics, committed to a biologically grounded view of gender development, have claimed that this diversity is largely illusory. But given the view of development I have just presented there is no reason to suppose that things are not as they so clearly seem. The institutions and norms surrounding gender development have diverged in different places and over time, and the gender system has changed too.

Let me finally take up the idea just mentioned of norms. Gender is, of course, thoroughly norm-ridden. We teach our children how boys and girls, men and women ought to behave, and often that they ought to behave differently from each other. The importance of norms, and many central points of the foregoing discussion, can be nicely illustrated with a brief consideration of the issue of homosexuality. Homosexuality is, of course, a huge problem for the very prominent kind of biological determinism, or at any rate biological causality, inferred from reflections on evolution. Prima facie, at least, homosexuality seems a poor strategy for maximising one's reproductive success. Sociobiologists and evolutionary psychologists have battled manfully (I use the word advisedly) with the problem. Perhaps ur-homosexuals worked very hard at raising their nephews and nieces, and the genes for homosexuality that they had some chance of sharing with these young relatives were thereby favoured. This is, of course, nonsense, not least because there are no genes for homosexuality or, perhaps better, there are so many genes for homosexuality—genes that in more or less subtle ways affect the probability of becoming homosexual in specific environments—that it would be better to say there were none. It is also the worst kind of just so story: beyond the fact that it might possibly explain an anomaly in a dominant system of ideas it has no evidence going for it at all.

Being gay, lesbian, or straight, is a developmental outcome[20]. Like all human developmental outcomes it results from a complex interaction between internal, including genetic, and external causes. Crucially, the latter are partly normative. Liberal societies do not, I think, now mandate heterosexuality, though no doubt they favour it, but they do mandate a dichotomy. One is one thing or the other.

[20] What follows here has an obvious debt to Michel Foucault (1979 [1976]). I also continue to follow Anne Fausto-Sterling (2012).

When men or women after decades of heterosexual marriage take up homosexual relations it is generally said that they have discovered that they were gay or lesbian. Their marriages are discovered to have embodied a gross failure of self-knowledge. Teenagers who feel attracted to members of their own sex agonize over whether they are gay, or whether this is some passing anomaly of desire. As with sex, this dichotomy is not an immediate problem for the many people who have no doubt on which side of the line they fall. And the suggestion that the division is a normative one is often unwelcome to the unambiguously homosexual, who understandably feel that a quasi-biological dichotomy is a solider ground for defending their lifestyle than a normative dichotomy. However, since the pioneering studies of Alfred Kinsey over 60 years ago (Kinsey et al., 1948, 1953), it has been quite clear that in terms of the behaviour generally supposed to define these categories people lie on a spectrum, with many engaging in sexual activities with members of their own and the opposite sex at various stages of their lives. Nowadays it is common to distinguish not only straight, gay and lesbian people, but also bisexual, transgendered, and queer—a category that is best defined by its refusal to accept a category. No doubt there are many strata of society in which heterosexuality remains normative; but it is increasingly clear that maintaining this norm, and the normativity of the dichotomy between straight and gay, will be difficult as a growing number of people refuse to accept it. Actual developmental histories produce mixed and diverse objects of sexual desire. Sexuality, very possibly, is leading the way where even sex may eventually follow.

A final striking perspective on the ontogeny of desire, the developmental process that leads to the preference of one object of sexual desire over another, is provided by the much-debated issue of pornography. Prominent feminists have suggested that pornography, or certain forms of pornography, may promote violence against women or normalise various demeaning treatments of women. This may well be so. Psychiatrist Norman Doidge (2007) provides a compelling and disturbing argument that pornography can, at any rate, radically reshape sexual desire. He describes patients becoming increasingly addicted to pornography and simultaneously increasingly unable to become sexually excited by their live partners. He also describes the evolution of pornography from the relatively uncomplicated depiction of sexual intercourse to the growing menu of violent, abusive, or just plain bizarre genres currently available on the internet. He even reports that consumers of internet pornography may reach a state where they are sexually aroused not just by thinking about the activities performed in pornography, but by thinking of the computer itself. Even if the simplistic evolutionary psychological stories about universal preferences for ideally curvy female figures (Singh 1993) proved true as statistical averages, they would be irrelevant for understanding the diversity and plasticity of desire. Desire, it appears, is almost indefinitely malleable, and can be shaped in the most unexpected ways.

Conclusion

Let me conclude. The picture I have sketched is one in which both male and female sex and male and female gender point to the most typical outcomes of developmental processes, but outcomes from which many individual trajectories diverge. At birth, or perhaps sooner as prenatal surveillance becomes more and more routine, the male/female dichotomy of sex is normatively enforced, with medical intervention common in response to atypical individuals. This dichotomy is then the basis for a more systematically normative enforcement of dichotomous gender development. While it is still commonly supposed that both stages of this process are largely determined by genes, the growing understanding of the complexity of human development, and the deep entanglement of internal and external influences that development involves, make this kind of genetic determinism wholly implausible. An essentialist perspective on sex or gender is disastrously misguided.

So what should we make of the sex/gender distinction with which I began this talk? Sex is an important biological concept and it is, of course, central to human reproduction; gender is a diverse and malleable superstructure erected socially on this biological base. Nevertheless, there are reasons, in the end, not to make too sharp a distinction between the two. The distinction between male and female sexes is important, but not wholly sharp. There are many individuals who fall in the gap between these two kinds, and there is much to be said for relaxing the normative requirement of sexual dichotomy. Moreover sexual differentiation is no more immune to external, especially epigenetic, influences than are other aspects of physiological development. These influences may well include aspects of gender, so that the system of gender differentiation may act causally on the physiological articulation of sex. Though I think that the distinction between sex and gender will continue to be pragmatically useful, most fundamentally it may be better to think of sex/gender as one seamless axis of differentiated development. But of course this is not the pair of predetermined developmental tramlines imagined by genetic determinists; rather we should see broad and well-trodden pathways within a much wider range of more esoteric possibilities, perhaps ever widening as we increase our tolerance of difference. Those whose sex/gender development lies some way from these pathways should be welcomed, not least as reminders of the flexibility and open texture of the human developmental process. If there is a boundary between sex and gender, it is a moving and slippery one. But no problem with that. That's what biological –and social-- boundaries are like.

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