# Nature v nurture:
# is sexual orientation inherited?

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**Nature v nurture: is sexual orientation inherited?**

Humans are sexual beings: we reproduce sexually, and part of our identity as people is in our gender. But to what extent is human sexual orientation directed by our biology? This is a question over which a great deal of ink has been spilled and much disagreement generated. Cutting as it does to an aspect of our humanity which is fundamental and deeply seated, it is an emotive issue. The available scientific evidence may be difficult to interpret, and, rather than being evaluated fairly, is often deployed to support an entrenched position. But what does the science actually tell us about sexual orientation, and are there other factors which must be taken into account in what is often referred to as the "nature versus nurture" debate?

The purpose of this paper is to attempt to offer a balanced review of the scientific literature on research into human sexual orientation. While it is recognised that evidence other than that which science can provide must be taken into account (e.g. theological and ethical considerations), this paper consciously does not address these. This is not intended to suggest that scientific evidence is paramount, but reflects the parameters of the task agreed with Lord Hodge[1].

**What science can and cannot do**

Science does not seek to determine what is correct in the sense of being morally "right". While scientists may sometimes like to be thought of as the ultimate arbiters of "truth", science does not normally seek to discern what is "right" - that question is largely for disciplines other than science, such as ethics and philosophy.

Science deals in statistics, correlations and disagreement, in seeking to discern what is going on in the world around us. Thus, as will be seen in this paper, different studies seeking to answer questions around human sexuality sometimes produce contradictory conclusions. In many ways this is ultimately how science works: while in the eyes of the general public science "proves" something (and, in truth, we as professional scientists do little to disabuse them of this view), in actual fact the opposite is true. Properly speaking, a "null" hypothesis (e.g. action X does not lead to

[1] This paper has largely been authored by Dr Murdo Macdonald, Policy Officer of the Society, Religion and Technology (SRT) Project of the Church of Scotland. Dr Macdonald is a molecular biologist with 20 years research experience, who now works full time for the SRT Project, helping the church engage with ethical issues in science. In October 2009, Lord Hodge met with Dr Macdonald, Rev Ian Galloway (Convener, Church and Society Council) and Rev Ewan Aitken (Secretary, C&S Council). At this meeting it was agreed that Dr Macdonald draft this paper for the Assembly Special Commission.

consequence Y; Gene A is not linked to observed trait B) is proposed, and evidence sought to test whether this accords with the observed population - to disprove the null hypothesis. Thus, particularly in biology, it is very rare to be able to say with absolute certainty that something is incontrovertibly proven.

The rules under which scientific investigations are carried out strive to eliminate bias: for example, in the section of the subjects to be recruited into a study, or in interpreting the results of an experiment. However, it must be recognised that it is virtually impossible to ensure that all bias has been completely eliminated. Care in the selection of participants in studies is of fundamental importance - especially in relation to complex, difficult-to-quantify traits.

Finally, scientists are human. We are drawn to study what interests us, and motivated to spend careers designing experiments and analysing results by a variety of drivers. These drivers, in common with other disciplines, might include a desire to make money or achieve fame, and may be influenced by personal interests, beliefs or world-views. This fact must be acknowledged in a field as contentious as the one in question. In addition, our passion can be a double edged sword: if we have gained grant funding or achieved recognition by pursuing a particular hypothesis, it may be difficult to countenance evidence to the contrary.

**Sex and sexuality**

While acknowledging that not all sexual activity is undertaken in order to procreate, from a purely biological point of view the primary purpose of sex is reproduction: to produce offspring in order to continue the existence of the species. Many species reproduce without sex, and the question as to why and how sexual reproduction arose is one which continues to puzzle scientists. Among the many biological advantages of sexual reproduction is the ability to mix the gene pool when two different individuals of the same species mate, but from a purely mechanistic perspective, sexual reproduction seems much less efficient than other ways in which organisms reproduce (budding of daughter cells in yeast, for example). However, most complex “higher” organisms (including humans and other mammals) reproduce sexually.

Sexual reproduction leads to gender, each with specialised roles in the reproductive process, and to a differentiation between the genders - both in terms of gametes (sperm *v.* egg production) and external and internal organs related to reproduction. Again, throughout biology a variety of means of organising that differentiation is apparent. In some species (e.g. snails) all individuals are hermaphrodite - i.e. have both male and female sexual structures.

In humans, hermaphrodism is possible but is very much the exception. Anatomical differentiation between male and female humans seems to be largely controlled by the "sex chromosomes" - referred to as X and Y, males normally being XY and females XX. A single gene (called "sex-determining region Y", or SRY) on the human Y chromosome seems to act as a signal to set the developmental pathway towards maleness; other mammals use several genes on the Y chromosome for that same purpose. However, although this represents the normal pattern, humans can have a chromosomal arrangement which is contrary to their phenotypic sex, that is, XX males or XY females. The recent high-profile controversy over the South African runner Caster Semenya, who is phenotypically female but is genetically described as "intersex", illustrates the existence of the spectrum of sex chromosome configurations which is possible within human populations.

**Genes and gender**

Gender is a part of sexual orientation and attraction: if there were no sexual reproduction, there would be no requirement for different genders. However, as illustrated above, differentiation between the genders is not always as clear-cut as might be considered "normal". Although, perhaps not surprisingly, some of the genetic loci which have been associated with homosexuality are located on the sex chromosomes and are perhaps involved in anatomical gender determination, the association between the irregular chromosomal arrangements described above and sexual orientation is as yet unclear.

Differences within human populations may be influenced by many factors, including specific genes, hormones, anatomy, or social learning. Some of the differences are entirely physical (e.g. presence of a uterus) and some differences are just as obviously purely a matter of social learning and custom (e.g. relative hair length). Many differences, though, such as gender identity, appear to be influenced by both biological and social factors.

Many of the studies into factors which determine sexual orientation look at the DNA. The genetic configuration of an individual (their DNA sequence) is inherited from their parents, is largely established at fertilisation (when the sperm fuses with the egg), and remains essentially unchanged throughout the lifetime of that individual.

This means that it is possible to assess the DNA sequence of an individual at any point in their lives, and to make a correlation between an observed trait and a particular DNA sequence - sometimes referred to as “genetic linkage” or “genetic susceptibility”[2]. The stability of the DNA sequence should make assessing the influence of genes on behaviour relatively straightforward. In contrast, many other potential influences on development (e.g. hormonal differences *in utero*, social influences) can and do change over time, and it is therefore much more difficult to assess with certainty what long term influence they have.

The early stages of differentiation in the human embryo appear to be quite similar to the same biological processes in other mammals, in which the interaction of genes, hormones and body structures is fairly well understood. In the first weeks of life, an embryo has no anatomic or hormonal sex, and only an examination of the chromosomes distinguishes male from female. As the embryo develops, the expression of specific genes induces gonadal differences, which produce hormonal differences, which cause anatomic differences, leading to psychological and behavioural differences. However, as these *in utero* influences are by definition transient and, in practice, impossible to measure in humans, assessing their long term influence is difficult. For this reason, a number of proxies for hormonal influences have been identified and studied. These include differences in skeletal size and shape, including the ratio of the long bones of the arms and legs relative to arm span or stature and the hand bones of adults (the ratio of the length of the various phalanges).

**The brain**

The brain has been studied extensively. Since brain activity probably has a large influence in initiating and maintaining sexual attraction, researchers have examined the question of sexual orientation by studying the brain. While we are still in the relatively early stages of fine mapping the activity of the brain, much work has been done on comparing the anatomy of brains. Early studies showed that two of four Interstitial Nuclei of the Anterior Hypothalamus (INAH) were at least twice as large in males as females. Since the INAH is known to be involved in sexual dimorphism in other animals, it was hypothesized that there might be differences in this region in heterosexual *vs*. homosexual men. A number of studies have shown differences, but

[2] For technical reasons, in human studies genetic linkage is normally to a region of a chromosome which is much larger than what would properly be thought of as a single “gene”

have produced contradictory results[3]. The role of the hypothalamus in sexual orientation has been further studied by Swaab *et al*[4]. Other researchers had hypothesized that differentiation of the hypothalamus occurred before birth. However, Swaab's study showed that the sexually dimorphic nucleus (SDN) of more than 100 subjects decreased in volume and cell number in the females only 2 - 4 years postnatal. This observation complicated the findings of brain studies, since not only chemical and hormonal factors, but also social factors, might have influenced this process during the first few years of life.

A study by Allen and Gorski[5] examined the anterior commissure of the brain, finding that females and homosexual males exhibited a larger size than heterosexual males. However, later studies using larger sample sizes failed to find such differences[6]. More recently, studies using techniques such as magnetic resonance imaging (MRI), which assess brain activity (as opposed to brain structure), have indicated differences between participants with differing sexual orientations[7]. Other studies looking at aspects of brain function (such as sexual arousal and startle responses) have similarly indicated differences between those exhibiting different sexual orientation[8]. However, many of these studies use small numbers of participants (often fewer than 100 participants in total). Perhaps more importantly, many of the findings reported have not been repeated or independently verified.

Complicating the issue of brain differences between homosexuals and heterosexuals is the problem that experiences, including sexual experiences, can affect brain

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[3] An initial study by LeVay (Science 253:1034-1037 (1991)) showed a difference in hypothalamic structure between heterosexual and homosexual men. However, a subsequent (larger) study by Byne *et al* (Horm. Behav. 40: 86-92 (2001)) found no statistically significant difference between the groups.

[4] Swaab D.F., L.J. Gooren and M.A. Hofman: *Gender and Sexual Orientation in Relation to Hypothalamic Structures.* Horm. Res. 38 Suppl 2: 51-61 (1992)

[5] Allen, L.S. and R.A. Gorski: *Sexual orientation and the size of the anterior commissure in the human brain.* Proc Nat'l Acad Sci USA 89: 7199-7202 (1992)

[6] Lasco, M.S., T.J. Jordan, M.A. Edgar, C.K. Petito and W. Byne: *A lack of dimorphism of sex or sexual orientation in the human anterior commissure.* Brain Research 936: 95-98 (2002)

[7] Savic, I. and P. Lindstro¨m: *PET and MRI show differences in cerebral asymmetry and functional connectivity between homo- and heterosexual subjects*. Proc Nat'l Acad Sci USA 105: 9403–9408. (2008)

[8] See for example Rahman, Q., V. Kumari and G.D. Wilson: *Sexual orientation-related differences in prepulse inhibition of the human startle response.* Behavioral Neuroscience. 117: 1096-1102 (2003); Barch, B.E., P.L. Reber, M.R. Levitt, D.R. Gitelman, T.B. Parrish, M.M. Mesulam and J.M. Bailey: *Neural correlates of sexual arousal in heterosexual and homosexual men.* Proceedings of the Society for Neuroscience Annual Meeting (2003).

structure[9]. Thus the question of cause and/ or effect with regard to observed differences in the brains of people exhibiting differing sexual orientations remains: whether homosexual practice changes the brain or the brain results in homosexual practice.

Another complicating factor in interpreting much of the evidence is the observation that, for some at least, sexual preference does seem to change over time. For example, a 5-year study of lesbians found that over a quarter of these women relinquished their lesbian/ bisexual identities during this period[10]. In a survey of young women (16 - 23 years of age), half of the participants changed their sexual identities more than once during the two-year survey period.[11] In another study of 156 subjects who were recruited from organizations which serve lesbian/ gay/ bisexual youths (ages 14 to 21 years) in New York City, the percentage who changed from a lesbian/ gay/ bisexual orientation to a heterosexual orientation was 5% over the 12 month period of the study[12]. Other studies have confirmed that sexual orientation is not fixed in all individuals, but can change over time, especially in women[13]. Although many of these studies have been carried out in younger populations, the paper by Kinnish *et al*[13] is interesting in that many of the subjects involved in that study were in a slightly older age group (36 – 63 years). These findings suggest that, for at least some individuals, sexual orientation appears to be something over which they exercise a degree of choice.

**Cognitive studies**

In general, women and men differ in a number of cognitive traits. Men tend to outperform women in certain kinds of visuospatial tasks, such as mental rotation and targeting, as well as in mathematical reasoning, whereas women tend to outperform men in tests of verbal fluency (speed at coming up with words that correspond to

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9 Breedlove, S.M.: *Sex on the brain.* Nature 389: 801 (1997)

10 Diamond, L.M.: *Was it a phase? Young women's relinquishment of lesbian/ bisexual identities over a 5-year period.* J. Pers. Soc. Psychol. 84: 352-64 (2003)

11 Diamond, L.M.: *Sexual identity, attractions, and behavior among young sexual-minority women over a 2-year period.* Dev. Psychol. 36: 241-50 (2000)

12 Rosario M., E.W. Schrimshaw, J. Hunter, and L. Braun: *Sexual identity development among gay, lesbian, and bisexual youths: consistency and change over time.* J Sex Res. 43: 46-58 (2006)

13 Kinnish, K.K., D.S. Strassberg and C.W. Turner: *Sex differences in the flexibility of sexual orientation: a multidimensional retrospective assessment.* Archives of Sexual Behavior 34: 173–183 (2005)

some category), speed of calculation, recognition of facial expressions, and memory of object location[14].

A number of studies have reported that homosexual men perform worse than heterosexual men on a variety of visuospatial tasks[15]. However, other such studies failed to find differences between homosexual and heterosexual men[16]. Findings for women have also been mixed.

The study by Rahman and Wilson (2003) cited above found that homosexual men do better than heterosexual men in object location memory tests; no difference between the performance of lesbian and heterosexual women was found. Similarly, a 1991 study reported that homosexual men outperform heterosexual men in verbal fluency tests, but two subsequent studies came up with negative results[17].

***In utero* hormonal effects**

A number of scientists, especially the German neuroendocrinologist Günter Dörner, have promoted a prenatal hormonal theory of homosexuality[18]. This theory postulated that in human foetuses destined to become homosexual adults, the sexual differentiation of the brain proceeds in a sex-atypical direction. Although the prenatal hormonal theory has not been proved or disproved in the decades since Dörner proposed it, it is probably the dominant idea among those who think about sexual orientation from a biological perspective.

A number of studies have shown that ratios of digit length are predictors of several hormones, including testosterone, luteinising hormone and oestrogen. In women, the index finger (2D, second digit) is almost the same length as the fourth digit (4D). However, in men, the index finger is usually shorter than the fourth. It has been

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[14] Kimura, D. (1999). *Sex and Cognition*. MIT Press

[15] See, for example, Wegesin, D.J.: *A neuropsychologic profile of homosexual and heterosexual men and women.* Archives of Sexual Behavior. 27: 91-108 (1998); Rahman, Q. and G.D. Wilson: *Large sexual-orientation-related differences in performance on mental rotation and judgment of line orientation tasks.* Neuropsychology. 17: 25-31 (2003)

[16] See Gladue, B. A., W.W Beatty, J. Larson, and R.D. Staton: *Sexual orientation and spatial ability in men and women.* Psychobiology. 18: 101-108 (1990); Tuttle, G.E. and R.C. Pillard: *Sexual orientation and cognitive abilities.* Archives of Sexual Behavior. 20: 307-318 (1991)

[17] McCormick, C.M. and S.F. Witelson: *A cognitive profile of homosexual men compared to heterosexual men and women.* Psychoneuroendocrinology. 16: 459-473 (1991); Gladue, B.A., W.W Beatty, J. Larson and R.D. Staton: *Sexual orientation and spatial ability in men and women.* Psychobiology. 18: 101-108 (1990); Neave, N., M. Menaged and D.R. Weightman: *Sex differences in cognition: the role of testosterone and sexual orientation.* Brain and Cognition. 41: 245-262 (1999)

[18] Dörner, G.: *Zur Frage einer neuroendocrinen Pathogenese, Prophylaxe und Therapie angeborenen Sexualdeviationen*. Deutsche Medizinische Wochenschrift. 94: 390-396 (1969)

shown that this greater 2D:4D ratio in females is established in two-year-olds, and it has been hypothesized that the sex difference in the 2D:4D ratio reflects the prenatal influence of androgen on males. A study by Williams *et al*[19] showed that the 2D:4D ratio of homosexual men was not statistically significantly different from that of heterosexual men for either hand, while homosexual women displayed significantly smaller 2D:4D ratios compared with heterosexual women. However, other studies utilising this ratio have produced contradictory results: some showing that homosexual men have a lower 2D:4D ratio than heterosexual men, others a higher ratio and others no difference[20]. Another study found that males who had two or more older brothers were statistically significantly more likely to develop a homosexual orientation and were also found to have a lower 2D:4D[21]. A further study, by Martin and Nguyen [22], examined the length of long bones in the arms, legs and hands. Both homosexual males and heterosexual females had less long bone growth in the arms, legs and hands, than heterosexual males or homosexual females - in contradiction of the results of the Williams study above, which appeared to show that males with multiple older brothers (who tended to be homosexual) experienced increased androgen exposure. The influence of androgen levels (as assessed using these proxies) on sexuality therefore remains a matter of debate.

**Gathering the evidence isn't easy**

The various ways in which influences such as genes, hormones and upbringing affect different human behaviours and mental traits are difficult to test experimentally. However, while the genetic composition of a human is stable and thus relatively easy to assess, it is also becoming increasingly recognised within the scientific community that the interaction between the genes and their environment is important - that living organisms are much more than simply machines driven by their DNA.

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[19] Williams *et al*: *Finger-length ratios and sexual orientation.* Nature 404: 455-456 (2000)

[20] See McFadden, D. and E. Shubel: *Relative lengths of fingers and toes in human males and females.* Hormones and Behavior. 42: 492-500 (2002); Rahman, Q. and G.D. Wilson: *Sexual orientation and the 2nd to 4th finger length ratio: evidence for organising effects of sex hormones or developmental instability?* Psychoneuroendocrinology. 28: 288-303 (2003); Lippa, R. A.: *Are 2D:4D finger-length ratios related to sexual orientation? Yes for men, no for women.* Journal of Personality and Social Psychology. 85: 179-188 (2003)

[21]McConagh, N., D. Hadzi-Pavlovic, C. Stevens, V. Manicavasagar, N. Buhrich, and U. Vollmer-Conna: *Fraternal birth order and ratio of heterosexual/homosexual feelings in women and men.* J. Homosex. 51:161-74. (2006)

[22] Martin, J.T. and D.H. Nguyen: *Anthropometric analysis of homosexuals and heterosexuals: implications for early hormone exposure.* Hormones and Behavior 45: 31-39. (2004)

The whole area of the role of biological, as opposed to "environmental" factors, can be a very complex one. Investigation of these depends on some fairly complex technical concepts, some pretty heavy statistics, and some difficult-to-design scientific studies. For example, defining "case" v. "control" groups and determining required sample sizes can be challenging, as can the interpretation of the results obtained.

While some genetic diseases in humans (e.g. cystic fibrosis) are inherited on the basis of changes in a single gene, most traits which have a genetic component display what is termed "multi-gene" inheritance - for example, susceptibility to heart disease is variable, dependent on the combination of the variants of a number of genes which a person carries.

The example of genetic susceptibility to heart disease also illustrates the difficulty of setting genetics and environment entirely in opposition, as is frequently done. This dichotomy is often false, and the interplay between these elements complex. Thus an individual who carries a set of genes which in theory makes them very susceptible to heart disease can alter their environment (i.e. diet, exercise, non-smoking) in such a way that, essentially, their genes are irrelevant to the outcome. Conversely, somebody with relatively low genetic risk factors may, through their behaviour, over-ride their genetic advantage, with the opposite outcome. Humans have the ability to over-rule their genes: Richard Dawkins recognised as much in his famous book "*The Selfish Gene"* - although, according to his hypothesis, our genes may drive us to be selfish, acquisitive or promiscuous, we can choose not to let these traits dictate how we behave[23].

Each individual human carries two copies of every gene. For any given gene in a population, there will be a number of variants - some of which may confer susceptibility to a particular trait, some of which may have a protective effect - and many of which do neither.[24]

**History**

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[23]Dawkins, R.: "The Selfish Gene". Oxford University Press (2006)

[24] Perhaps confusingly, the measurement of this variation uses the term "heritability". Although the terms are sometimes used interchangeably (particularly by the media), this is NOT the same concept as "inheritance". Inheritance means "directly determined by the genes". While we inherit one copy of each gene from each parent, heritability refers to the proportion of variation between individuals in a population that is influenced by genetic factors. Heritability describes the population, not individuals within that population. Thus an inherited characteristic (e.g. eye colour) also displays a degree of heritability.

As the technology to study the DNA sequence of individuals has progressed, many studies have been conducted which have used analysis of the genes of populations to try to discern which genes play an important role. Identifying areas of the genome which are of relevance to the issue of interest often involves what are termed "genetic linkage studies". Genetic linkage occurs when particular genetic loci or alleles for genes are inherited jointly. Genetic loci on the same chromosome are physically connected, so tend to stay together through successive generations, and are thus genetically linked.[25] The chromosomal distance between two genes can be calculated using the offspring of an organism showing two linked genetic traits, and finding the percentage of the offspring where the two traits do not run together. The higher the percentage of descendants that does not show both traits, the farther apart on the chromosome the two genes are.

Among the first major studies of homosexuality to use such genetic techniques was a paper entitled "*A linkage between DNA markers on the X chromosome and male sexual orientation."* published by Hamer *et al* in the journal *Science* in 1993[26], which indicated that there was a region of the X-chromosome which was linked to homosexual orientation. Almost inevitably, the term "gay gene" was adopted by the media - though not the scientific community, as the term lacks accuracy. The term has also penetrated public consciousness and (arguably) influenced debate. However, one of the few things which can be said with some certainty in relation to this area is there is no single "gay gene". Sexual orientation is not controlled by a single genetic locus.

**Interpreting the evidence isn't always easy**

Proving a connection between an observed genotype (i.e. genetic make up of an individual) with an observed phenotype (a real-world outcome - in the case of sexuality, behaviour) takes us into the realms of some very complex statistics. Many studies in human genetics are complicated by the fact that most human populations are what are termed "out-bred".[27]

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[25] Alleles for genes on different chromosomes are usually not linked, due to independent assortment of chromosomes.

[26] Hamer, D.H., S. Hu, V.L. Magnuson, N. Hu and A.M. Pattatucci: *A linkage between DNA markers on the X chromosome and male sexual orientation.* Science 261: 321-327 (1993)

[27] In contrast, many studies in mice for example use "in- bred" strains, where selective breeding in the laboratory over many generations has produced populations of mice which are genetically virtually identical- making it easier to unpick the role of genes in a process, and to identify which genes are important

Identical twins are naturally genetically identical. Accordingly, there have been a number of studies which have sought to use twins to look at many questions in human biology - including sexual orientation. Siblings and non-identical twins share about 50% of their genes, so are also useful in such studies. Studies have shown, for example, that a man with a homosexual sibling is about 5 times more likely to themselves be homosexual in orientation[28]. However, these results in themselves do not distinguish between biological and environmental influences

Twin studies usually look for "concordance", defined as the probability that a pair of individuals will both have a certain characteristic; given that one of the pair has the characteristic. For example, twins are concordant when both have or both lack a given trait. Studies have come up with a concordance rate of approximately 50% for male monozygotic ("identical") twins compared with 22% for male dizygotic ("non-identical) twins, and for female twins concordances of 48% and 16% respectively [29]. A study by Kendler *et al*. in 2000 examined 1,588 twins selected by a random survey of 50,000 households in the United States[30]. This study found that 3% of the population consisted of non-heterosexuals (homosexuals and bisexuals) and a genetic concordance rate of 32% - i.e. when one twin was homosexual, in approximately a third of cases their twin sibling shared their sexual orientation. The study lost statistical significance when twins were broken down into male and female pairs, because of the low rate (3%) of non-heterosexuals in the general U.S. population.

Twin studies suffer from the problem of trying to distinguish between environmental and genetic factors, since twins tend to live within the same family unit. There is one small study of monozygotic twins reared apart[31]. Of four female pairs in which one twin was lesbian, none of the co-twins were lesbian; of two male pairs in which one twin was homosexual, one of the co-twins was also homosexual, while the other was bisexual.

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[28] Pillard, R.C. and J.D. Weinrich: *Evidence of familial nature of male homosexuality.* Archives of General Psychiatry. 43: 808-812. (1986)

[29] Bailey, J.M. and R.C. Pillard, R. C.: *Genetics of human sexual orientation*. Annual Review of Sex Research. 6: 126-150 (1995); Bailey, J.M., R.C. Pillard, M.C. Neale and Y. Agyei: *Heritable factors influence sexual orientation in women*. Archives of General Psychiatry. 50: 217- 223 (1993)

[30]Kendler, K.S., L.M. Thornton, S.E. Gilman and R.C. Kessler: *Sexual Orientation in a U.S. National Sample of Twin and Non-twin Sibling Pairs*. Am. J. Psychiatry 157:1843-1846. (2000)

[31] Eckert, E.D., T.J. Bouchard, J. Bohlen and L.L. Heston: *Homosexuality in monozygotic twins reared apart.* British Journal of Psychiatry. 148, 421-425 (1986)

A study examining the effect of birth order on homosexual preference concluded, "The lack of relationship between the strength of the effect and degree of homosexual feelings in the men and women suggests the influence of birth order on homosexual feelings was not due to a biological, but a social process in the subjects studied."[32]. So, although twin studies suggest a possible genetic component for homosexual orientation, the results do not appear to be definitive.

**Statistics**

Many of the outcomes of studies in human genetics are interpreted in terms of statistical significance. This in turn is influenced by a number of factors: for example, the population which is included in the study, and the "control" population with which it is compared. In addition, the availability and choice of what are termed "informative markers" in genomic studies plays an important role.

Finally, the statistical analysis employed is crucial - as is the recognition of "confidence limits". Levels of statistical significance are often set at 95%, meaning that 5% (i.e. 1 study in 20) which appear to show an association between a genotype and a phenotype are in fact due to chance. In addition, it should be noted that, if a genetic association is sought, an association (at some level of statistical significance) will be found; the biological meaning of such an association may be difficult to discern. For example, recent studies have found a genetic predisposition to homophobia, opposition to abortion and credit card debt[33].

Subsequent to the initial study by Hamer *et al*[26], a number of other studies have been conducted in this area - many coming up with contradictory results. For example, attempts by Rice *et al*[34] and an unpublished study[35] failed to replicate the Hamer results.

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[32] McConaghy, N., D. Hadzi-Pavlovic, C. Stevens, V. Manicavasagar, N. Buhrich, and U. Vollmer-Conna: *Fraternal birth order and ratio of heterosexual/homosexual feelings in women and men.* J. Homosex. 51:161-74. (2006)

[33] Verweij K.J., S.N. Shekar, B.P. Zietsch, L.J. Eaves, J.M. Bailey, D.I. Boomsmaand N.G. Martin: *Genetic and Environmental Influences on Individual Differences in Attitudes Toward Homosexuality: An Australian Twin Study.* Behav. Genet. 38: 257-265. (2008); Eaves, L.J. and P.K. Hatemi: *Transmission of Attitudes Toward Abortion and Gay Rights: Effects of Genes, Social Learning and Mate Selection.* Behav. Genet. 38: 247–256. (2008); LSE Research, Spring 2010 (http://www2.lse.ac.uk/newsAndMedia/publications/pressOfficePublications/LSEResearch.pdf)

[34] Rice, G., C. Anderson, N. Risch, and G. Ebers: *Male Homosexuality: Absence of Linkage to Microsatellite Markers at Xq28.* Science 284: 665-667. (1999)

[35] Alan Sanders (University of Chicago), cited in Wickelgren, I. 1999. *Discovery of 'Gay Gene' Questioned*. Science 284: 571.

A study using the recently developed technique of "genome-wide association scanning" (GWAS), a screening method which will allow geneticists to scan the entire human genome to search for associations between chromosomal loci (e.g. genes) and a given phenotype (e.g. homosexuality) in an unbiased manner, has uncovered some evidence of linkages to chromosomes 7, 8 and 10 - though not to the X chromosome as indicated by the initial Hamer study[36]. The researchers were not able to perform a statistical analysis to evaluate whether these results were due to chance or to the actual existence of genes influencing sexual orientation at any of the three locations identified.

**Conclusions**

What are we to conclude? Is there strong scientific evidence that homosexuality is inherited? The evidence is often difficult to interpret and controversial at best, but probably not. It is perhaps telling that, in many ways, the scientific community is moving from a position of confidence to one of more dubiety. For example, the stance of the American Psychological Association on this issue has recently changed. While the previous version of the APA brochure on this subject, "Answers to your questions: For a better understanding of sexual orientation and homosexuality", stated that:

> *"…biology, including genetic or inborn hormonal factors, play a significant role in a person's sexuality"*

the 2008 version of the brochure has been amended to state that:

> *"Although much research has examined the possible genetic, hormonal, developmental, social, and cultural influences on sexual orientation, no findings have emerged that permit scientists to conclude that sexual orientation is determined by any particular factor or factors."*[37]

Do my genes and my biology determine who I am? Yes - and no! While our genes certainly direct the development and maintenance of the physical structures which make up our bodies, we as humans have the ability to make choices about many of our behaviours.

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[36] Mustanski, B. S., M.G. Dupree, C.M. Nievergelt, S. Bocklandt, N.J. Schork, and D.H. Hamer: *A genome wide scan of male sexual orientation.* Human Genetics. 116, 272-278. (2005)

[37] See: American Psychological Association. (2008). "Answers to your questions: For a better understanding of sexual orientation and homosexuality." Washington, DC. www.apa.org/topics/sorientation.pdf. p. 2.

Science tells us much, but we are really only beginning to discover just how much more than our biology humans really are. Just as wealth is more than money, religion more than ritual, and relationships more than sex, our humanity is more than simply the interactions of chemicals.