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IS THERE A GAY GENE?

by Donald F. Calbreath

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Synopsis

The pressure to accept homosexual behavior is growing daily. A major argument for this acceptance is the belief that homosexuality is "inborn." Two major areas of research often put forth to support this position deal with genetics and brain structure. The search for a gene associated with homosexuality has not shown any reproducible findings. Studies of twins did not prove to support the idea of a genetic component to homosexuality. The contribution of genetics to this behavior appears to be minimal. Neuroscientist Simon LeVay argued in 1991 that there was a specific component of the hypothalamus that differed in size between homosexual and heterosexual men, although his research has never been replicated. More recent studies of different components of the brain show differences that might have some statistical significance, but also demonstrate a great deal of overlap between heterosexual and homosexual males. Reparative therapy (or "sexual reorientation therapy") has been shown to be somewhat effective in changing the homosexual orientation, but is strongly opposed by most of the mental health community and by gay activists. Validation of a scientific theory requires that other researchers find the same data when performing experiments. The lack of reproducibility in biological studies on homosexuality has been a major hindrance to our understanding of this disorder. Recent research in brain plasticity suggests that brain changes could be the result of experiences and environmental input. These data also have implications for new approaches to reorientation therapy. Biological processes may *influence* behavior, but do not *determine* it. Christians need to be better informed about the scientific issues, but always should couch their responses in a spirit of love.

California Supreme Court rules same-sex marriage legal. Politicians caught in homosexual activity. Celebrities headlined for possible "gayness." Congress debates the "don't ask, don't tell" policy for gays in military. Prominent pastors involved in homosexual liaisons. Major splits developing in many mainline churches over homosexuality.

Christians are experiencing pressure from all sides to accept homosexual practices as just another means of expressing sexuality. Scientific data are used to imply that homosexual behavior is something that is "hard-wired" into people: "God made us this way." Navigating through the complicated network of truths, semi-truths, and outright propaganda that are found in the debate requires reliable information.

WHO IS "GAY"?

In 1948, scientist and human sexuality researcher Alfred Kinsey had developed a seven-point classification for sexual behavior.[1] One end of the spectrum (zero or one) comprised those who are exclusively heterosexual and show no interest in any same-sex activity. The other end of the spectrum (six) is composed of those individuals who are exclusively interested in same-sex behavior, with no

interest in heterosexual activities. The middle categories (scales two through five) have varying degrees of interest in both heterosexual and homosexual activities. Although flawed in some respects, the scale shows that there is no clear dividing line between "heterosexual" or "homosexual."

It is necessary to distinguish between homosexual practice and homosexual orientation. A heterosexual individual may experiment with homosexual practices (which is especially true in adolescents), but have a definite heterosexual orientation. Prison populations see a great deal of same-sex activity that in no way indicates the sexual preferences of the individuals involved.

Language for describing people who engage in same-sex behavior is evolving. The shorthand abbreviation LGBT—which stands for lesbian, gay, bisexual, transgendered—currently describes the cluster of identifications that such people indicate (this article will not address bisexual or transgendered individuals). Language also now differentiates between lesbian (female) and "gay" (male) sexual practices and orientations. This is an important distinction to make because the vast majority of the research studies on causes of sexual orientation deal with male behavior.

What Is this "Gay Gene"?

A little background information is necessary before looking at research on the "gay gene." What is a gene and why is it important? The National Library of Medicine's Genetics Home Reference (provided by the National Institutes of Health) gives the following definition: "A gene is the basic physical and functional unit of heredity. Genes, which are made up of DNA, act as instructions to make molecules called proteins. In humans, genes vary in size from a few hundred DNA bases to more than 2 million bases. The Human Genome Project has estimated that humans have between 20,000 and 25,000 genes."[2] A gene, then, directs the manufacture of another molecule. That molecule usually, but not always, is a protein. This will have some sort of effect on certain biochemical processes in the body.

If there is a "gay gene," that segment of DNA must be responsible for the production of some biochemical that somehow influences same-sex behavior. Complex behavioral conditions, however, do not lend themselves well to this type of analysis. Schizophrenia, for example, is a disorder that has been studied intensively for decades. At present we do not know the causes of the disease. Genetic studies have not been clear-cut—there is obviously a genetic component, but this factor is not the only contributor to schizophrenia.[3]

GENETIC STUDIES AND "GAY GENES"

Another quick genetics lesson might be in order before exam-in-ing genetic contributions to homosexuality. The tradi-tional view concerning twins is that there are identical twins and fraternal twins. Identical twins result from the fertilization of a single egg by one individual sperm. This egg later splits in two. Fraternal twins are the product of fertilization of two different eggs by two different sperm cells. Identical twins have one-hundred percent of their genes in common, while fraternal twins have fifty percent common genes.[4]

A number of twin studies have been carried out to explore the genetic contribution to homosexuality, if there is one. Most of the early studies were very flawed because they were working with small numbers of twins, had questionable recruiting strate-gies, and were not often rigorous in their assessment of same- sex orientation.

Two recent studies were designed to overcome the criticisms of earlier research. One involved the use of a fourteen-thousand-person set found in a national Australian database.[5] The second used the database from the 2005–2006 population survey of all adult twins in Sweden.[6] Both studies showed that genetics contributed only thirty-five to thirty-seven percent to male sexual orientation. Neither of them

provided evidence for a strong genetic basic for homosexual be-havior, but pointed strongly to individual environmental fact-ors as the major influence. To date, these studies represent the most thorough research in the field.

THE SEARCH FOR THE "GAY GENE"

In the highly politicized climate of 1973, which was created by two years of disruptive behavior by gay activists,[7] the American Psychiatric Association declared that homosexuality was not a psychiatric disorder. There was still interest, however, in learning what caused people to become homosexual. Two major research studies in the 1990s brought renewed attention to the question. One focused on the possible existence of a "gay gene." The other dealt with supposed differences in brain structure between homosexuals and heterosexuals. Both studies were carried out by gay activists and both studies have been strongly challenged, but they opened the door for the argument, "We're born that way," that is often used now in the gay community.

Geneticist Dean H. Hamer and his coworkers[8] studied families in which there was at least one gay member. They also looked at a genetic analysis of gay brothers in another component of the study. Chromo-some analysis showed a correlation between homo-sexual be-havior (as reported to the team) and the existence of a unique site on the chromosomes of some of the research sub-jects. In addition, more than eighteen percent of the brother pairs did not show an inheritance of all the markers. Hamer's conclusion was that "it appears that Xq28 contains a gene that contributes to homosexual orientation in males."[9]

The tentative nature of these data can be seen in the "Discussion" part of the paper. Hamer states, "Our experiments suggest that a locus (or loci) related to sexual orientation lies within approximately 4 million base pairs of DNA on the tip of the long arm of the X chromosome…it is large enough to contain several hundred genes."[10] So there really isn't one "gay gene"; maybe there are hundreds of different ones.

Questions about Hamer's research came quickly. An editorial comment in a 1999 issue of Science[11] briefly detailed the disagreement that existed at that time between Hamer's study and those of other researchers. Two different studies did not find the linkage that Hamer had reported.[12] Hamer argued that the other scientists had not selected their subjects in the same way and missed the maternal link that Hamer found.

Hamer continued the attempt to find a specific bio-chemical link to homosexuality at the molecular level. In 2004 he published a study looking at a specific enzyme involved in the conversion of androgens (steroid hormones that help develop masculine characteristics) to estrogens (steroid hormones involved in developing feminine characteristics).[13] His group reasoned that there may be some differences in the prenatal exposure of the developing brain to androgens and estrogens that might explain some of the genetic data regarding male sexual orientation. No differences were found in the population studied, however, ruling out this potential biochemical explanation.

A 2005 study by Hamer and his group[14] attempted to identify several candidate genes more closely than did his 1993 paper. This study, interestingly, did not confirm the linkage he had reported in 1993. Several possible genes were identified, but there was no conclusive information about the relationship of any of these genes to male sexual behavior.

A recent comprehensive article summarizes the research and the confusion.[15] After surveying the literature on the gay gene and related issues, Kunzig concludes, "Right now there is no one all-inclusive solution to the Darwinian mystery of why homosexuality survives, and no grand unified theory of how it arises in a given individual." As a footnote to the controversy, Dean Hamer has redirected his research

efforts in other directions entirely.

OTHER BIOLOGICAL RESEARCH

While Hamer was creating a stir on the East Coast of the United States with his "gay gene" hypothesis, another scientist was developing a different line of research on the West Coast. Simon LeVay, a neuroscientist at the Salk Institute for Biological Studies in San Diego, California, studied the hypothalamus—a small tissue in the brain that regulates a large variety of hormonal processes, many of which are not associated with sex—and its connection, if any, to homosexuality.

LeVay's study[16] used brain tissues from autopsies in hospitals in California and New York. In most cases, he had somewhat incomplete histories of the individuals involved. Nineteen of the forty-one subjects studied were homosexual men, all of whom had died of AIDS, while sixteen were presumably heterosexual men, six of whom had died of AIDS. Six of the total subjects were women whom researchers assumed were heterosexual; one had died of AIDS. After fixing and sectioning the tissues, LeVay measured the volumes of four cell groups that were thought to be important. The only group considered to be of significance was the INAH-3 (INAH stands for "interstitial nuclei of the anterior hypothalamus").

There are some significant problems with LeVay's research. First, no one else has been able to replicate or repeat his study. In fact, no one else has ever seen the original slides that LeVay used to make his measurements. Second, most of his homosexual subjects had died of AIDS, but he did not show how the AIDS infection might have affected the specific brain structure. Third, the area studied had been very poorly defined anatomically; exactly what researchers were to measure was thus dependent on subjective decisions; especially since the area LeVay studied was about the size of a grain of sand. Fourth, the data showed that there was significant overlap between the size of INAH-3 in the brains of heterosexual and of homosexual men. Later studies on brain structure proved to be contradictory and inconclusive.

A 2008 study measured brain tissues and blood flow using MRI and positron emission tomography.[17] This study examined possible differences in the way heterosexual and homo-sexual brains processed certain cognitive tasks; the para-meters studied were not related directly to sexual behavior. Again, although the researchers reported that homosexual men had brain struct-ures that were more closely related to hetero-sexual women, the degree of overlap between homo-sexual and hetero-sexual men was quite great. What may be significant sta-tistically does not appear to be so in actuality. These types of tests will not allow a clear differentiation between heterosexual and homosexual males.

A small series of recent studies has suggested that second sons have a higher likelihood of being homosexual.[18] With the first son, the mother begins to develop a type of immunity to the male as blood from the two mixes during delivery. This immune response generates antibodies in the mother that react with male proteins during pregnancy with the second son. The studies hypothesize that these antibodies might somehow alter development of the brain in such a way that he is more likely to be born gay. At present, no specific antibodies have been identified to support this hypothesis.

A 2008 *Los Angeles Times* article[19] looks at a variety of bio-logical and physical measurements that have been used to compare gay and straight males. The writer concludes that there is currently no indicator that allows a reliable prediction of sexual orientation.

CAN HOMOSEXUALS REALLY CHANGE?

In 1973, Robert Spitzer, a psychiatrist at the Columbia University College of Physicians and Surgeons, led a successful effort to remove homosexuality from the list of psychiatric disorders. This came about in part because of Spitzer's seminal and controversial position paper on homosexuality submitted to the American Psychiatric Association that year.[20] While attending the 1999 annual meeting

of the American Psychiatric Association, he had contact with several ex-gays who were picketing the meeting.[21] They claimed that they had changed their sexual orientation from homosexual to heterosexual. Spitzer followed up and found that there was no good research literature available either to support or refute these claims, so he conducted his own research.

After studying a group of two-hundred individuals who had exper-ienced some sort of reorientation to a more heterosexual life-style, Spitzer submitted a paper reporting his results to the journal *Archives of Sexual Behavior*.[22] Journal editor Kenneth Zucker decided to publish the article along with several peer commentaries, as well as a final response by Spitzer, and to introduce the group of papers with his own editorial commentary.

The article created a great deal of controversy because Spitzer reported, "Thus, there is evidence that change in sexual orientation following some form of reparative therapy does occur in some gay men and lesbians."[23] Many of the responses to his research were critical, coming from professionals who did not see anything wrong with homosexuality and who disliked the religious bias of many of the survey participants. Other comments were more open to the possibility that psychiatry perhaps had erred in the earlier decisions about homosexuality and the possibility of change. Spitzer received a number of personal attacks from colleagues and from gay activists.

Zucker's editorial pointed out the significant deficiencies in the research literature regarding both "reparative therapy" (as it was called at that time) and "affirmative" therapies designed to help homosexuals adjust to their lifestyle.[24] He noted that both types of research lack a sound theoretical foundation and that the database is "primitive." He thus concluded, "It is difficult to understand how professional societies can issue any clear statement that is not contaminated by rhetorical fervor."

Research in this field has had little material added since Spitzer's first major paper on the topic. A survey of the National Library of Medicine database shows only four references under the term "homosexual reparative therapy" more recent than 2003 other than a few articles on the ethics of the practice. Since it is less offensive to homosexuals who do not believe there is anything to "repair," the term "sexual reorientation therapy" is coming to be more commonly used. Of the ten articles in the database that are found under "sexual reorientation therapy,"and published since 2003, only two deal with therapy outcomes (one of which is an example of successful therapy)[25] while seven articles in a series in the journal *Christian Bioethics* explore ethical issues in treatment. In a *Christianity Today* interview, Spitzer suggested two possible explanations for this. He stated, "The reasons are, number one, reparative therapists are not scientists—they don't do studies. The second reason is, if somebody proposed that the National Institute of Mental Health do such a study, I think almost certainly any gays in the study section would say this is a total waste of time. They would say: We already know it's hokum, so why do it?"[26]

One organization that is dedicated to helping homo-sexuals who wish to change is the National Association for Research and Therapy of Homosexuality (NARTH). This group is comprised of psychiatrists, psychologists, behavioral scientists, and professional counselors, as well as those with backgrounds in religion, law, and education. NARTH's mission statement, as posted on its Web site, says, "NARTH upholds the rights of individuals with unwanted homosexual attraction to receive effective psychological care, and the right of professionals to offer that care."[27] The association provides a variety of online research and educational resources for anyone who is interested in this issue.

What Would Constitute Real Proof?

The ongoing debate about whether homosexuality is inborn or somehow chosen can be confusing. Contradictory studies are published. There seems to be no clear-cut way to distinguish a homosexual person from a heterosexual one. If there is a biochemical marker that would be responsible for homosexual behavior, what would be its characteristics? How would it be recognized as a real

indicator? For research on the origins of homosexuality to be more reliable, it needs to implement each of the following.

The populations being studied need to be defined clearly. There currently is no clear-cut distinction between "heterosexual" and "homosexual." The most commonly used scale for categorization has seven gradations. Most early studies did not do a scale ranking. In contrast, the 2008 Proceedings of the National Academy of Sciences study on brain structure included a Kinsey scale and used only "maximally heterosexual" and "maximally homosexual" subjects (those scoring at one end of the scale or the other; there were no subjects with intermediate ratings). This type of care in subject selection will be necessary in order for any meaningful data to appear.

The marker must be reproducible. Different teams using different techniques should all get the same results. Using different techniques eliminates the possibility of having a measurement error in any specific method. To date, none of the research looking for any marker has been reproducible, except for studies that show a slight genetic influence, and that finding can be explained away.
The marker needs to distinguish the populations clearly. No marker to date is seen clearly in the homosexual population or in a significant number of the nonhomosexual population. Brain structure studies show considerable overlap between the two groups.

The research should allow no chance for observer bias. A neutral observer should be able to look at the data and draw conclusions based solely on the scientific evidence and not on any personal agendas. The two major areas of research, unfortunately, have been clouded by a certain amount of personal bias. Both Hamer and LeVay are open about their own homosexuality. Hamer, to his credit, knows his personal bias and recognizes the limitations of his research. In a November 1995 interview in Time magazine,[28] he states, "From twin studies, we already know that half or more of the variability in sexual orientation is not inherited. Our studies try to pinpoint the genetic factors, not to negate the psychosocial factors." LeVay, on the other hand, resigned his research position, returned all his grant money, and helped form a gay activist organization within a year after his paper on brain structure was published. His writing to date focuses on broader issues of interest to the homosexual community and he is no longer doing lab research.

Brain Plasticity and Homosexual Behavior

For decades it was thought that the childhood brain could form and change, but that things became hardwired in adulthood. The only later changes would be from injury, degeneration, or changes in numbers of synapses. Recent research, however, is showing a very different picture of the adult brain. It is now being seen as fluid and changeable, responsive to new experiences.

A 2007 Time magazine article[29] describes a number of studies showing changes in brain structure as a result of mental stimuli. Not only was the neural activity altered in piano students who "thought" the practice of a piece of music and obsessive-com-pul-sive patients who were trained to respond mentally to their compulsive behavior, but the actual physical structure of the brain was changed. The literature on brain structure in depression shows similar data. One typical study30 showed a decrease in the size of a specific portion of the brain in patients with unipolar depression. Researchers conducted a more detailed exploration of the phenomenon in 2007.31 The take-home lesson is that the adult brain is more flexible in structure than once thought and can under-go change as a result of psychological change in the person's life.

These lines of research have some obvious implications for the issue of homosexuality. With genetics on the sideline, research seriously must consider the question of later influences on the brain. Early childhood influences or physical or emotional experiences that could produce some alteration of brain structure —especially in susceptible individuals—are all possibilities that need to be explored.

Much research obviously would be ruled out immediately on legal and ethical grounds, but some promising areas of study exist. These findings also could be useful in designing and implementing more effective ways to carry out sexual reorientation therapy.

THE FALLACY OF GENETIC DETERMINISM

As knowledge of genetics increased, there was a steady growth in the attitude, "My genes made me do it." Research literature has reported on genes that it considered responsible for alcoholism, drug addiction, risk-taking, sexual promiscuity, infidelity, violence, and other forms of inappropriate behavior. One study even suggested that people's political leanings are partially determined by their genes.32 There is thus a widespread belief that genes determine actions and people behave certain ways because their biochemical makeup compels that behavior.

Proof for such a belief, however, is lacking. Biological pro-cesses that fully explain behavior do not exist. There are no obvious biochemical or genetic factors that would compel a person to engage in homosexual behavior.

Even if there are genes that influence specific behaviors, do we simply excuse the behavior because of this? Of course not. We don't just ignore the behavior of alcoholics, but try to help them. We would not excuse violent people, but get them the help they need. We all have normal sex drives, but we do not just allow them free rein. All these behaviors have adverse consequences, as does homosexual behavior.

HOMOSEXUALITY AND THE CHRISTIAN COMMUNITY

There is a definite divide today in how the Christian church deals with homosexual behavior. Most mainstream Protestant denominations have adopted interpretations of Scripture that celebrate homosexuality. Conservative Christians feel that the meaning of the Bible has not changed and that sexual behavior has limits. Churches are seeing increased pressure for the performance of same-sex marriage ceremonies. Preachers who speak out against homosexual practices are being accused of hate crimes in various parts of the world.

In the midst of all this, committed Christians need to be informed and prepared. Believers need to be aware of the scientific work that is increasingly failing to show the "inborn" nature of the homosexual. They need to be aware of the liberal bias of the media and raise a voice against it in our newspapers, radio, and television stations. Christians need to be knowledgeable about the tremendous hidden health issues associated with homosexuality. These approaches require information and ideas that can come from such publications as the Christian Research Journal.

More importantly, we as Christians need to be prepared in our hearts to fight the battle in front of us: in the classroom, in the political arena, and in the churches that will not stand for traditional biblical values. The battle, however, must be fought not in anger or hatred but in love. Christians must counteract the accusation of being "homophobic" in a society that is increasingly "Christianophobic."

Donald F. Calbreath, Ph.D., retired in 2006 after twenty-two years on the chemistry faculty at Whitworth University in Spokane, Washington. His research interests involve the relationships between brain neurochemistry and human behavior.

notes

1 "Kinsey's Heterosexual-Homosexual Rating Scale," Research Program, The Kinsey Institute, Indiana University, http://www.indiana.edu/~kinsey/research/ak-hhscale.html.

2 "What Is a Gene?" Handbook, Cells and DNA, Genetics Home Reference, a Service of the U. S. National Library of Medicine, http://ghr.nlm.nih.gov/handbook/basics/gene.

3 "The NIMH Genetic Study of Schizophrenia," National Institute of Mental Health, http://gauss.nimh.nih.gov/sibstudy.
4 http://www.britannica.com/EBchecked/topic/228983/human-genetics/50742/Identical-twins.
5 J. Michael Bailey, Michael P. Dunne, and Nicholas G. Martin, "Genetic and Environmental Influences on Sexual Orientation and Its Correlates in an Australian Twin Sample," Journal of Personality and Social Psychology 78, 3 (2000): 524–36.
6 Niklas. Langström, Qazi Rahman, Eva Carlström and Paul Lichtenstein "Genetic and Environmental Effects on Same-Sex Sexual Behavior: A Population Study of Twins in Sweden," Archives of Sexual Behavior (2008) (an e-publication prior to being in print).
7 Charles W. Socarides, "Sexual Politics and Scientific Logic: The Issue of Homosexuality," The Journal of Psychohistory 19, 3 (1992), http://www.geocities.com/kidhistory/ homopolo.htm.
8 Dean H. Hamer , Stella Hu, Victoria L. Magnuson, Nan Hu, and Angela M. L. Pattatucci, et al., "A Linkage between DNA Markers on the X Chromosome and Male Sexual Orientation," Science 261 (1993): 321–27.
9 Ibid., 325.
10 Ibid., 326.
11 Ingrid Wickelgren, "Discovery of Gay Gene Questioned," Science 284 (1999): 571.
12 See George Rice, Carol Anderson, Neil Risch, and George Ebers, "Male Homosexuality: Absence of Linkage to Microsatellite Markers at Xq28," Science 284 (1999): 665–67.
13 Michael G. DuPree, Brian S. Mustanski, Sven Bocklandt, Caroline Nievergelt, and Dean H. Hamer, "A Candidate Gene Study of CYP19 (Aromatase) and Male Sexual Orientation," Behavior Genetics 34, 3 (2004): 243–50.
14 Brian S. Mustanski, Michael G. DuPree, Caroline M. Nievergelt, Sven Bocklandt, et al., "A Genomewide Scan of Male Sexual Orientation," Human Genetics 116 (2005): 272–78.
15 Robert Kunzig, "Finding the Switch," Psychology Today, May/June (2008): 89–93.
16 Simon LeVay, "A Difference in Hypothalamic Structure between Heterosexual and Homosexual Men," Science 253 (1991): 1034–37.
17 Ivanka Savic and Per Lindström, "PET and MRI Show Differences in Cerebral Asymmetry and Functional Connectivity between Homo- and Heterosexual Subjects," Proceedings of the National Academy of Sciences 105 (2008): 9403–8.
18 David A. Puts, Cynthia L. Jordan, and S. Marc Breedlove, "O Brother, Where Art Thou? The Fraternal Birth-Order Effect on Male Sexual Orientation," Proceedings of the National Academy of Sciences 103 (2006): 10531–2.
19 Regina Nuzzo, "What Does Gay Look Like?" Los Angeles Times, June 16, 2008.
20 APA document reference number 730008, accepted for inclusion in the DSM-II in 1973, http://www.psychiatryonline.com/DSMPDF/DSM-II_Homosexuality_Revision.pdf.
21 Douglas LeBlanc, "Therapeutically Incorrect—Atheist Psychiatrist Argues That Gays Can Change," Christianity Today, April 2005, 94.
22 Robert L. Spitzer, "Can Some Gay Men and Lesbians Change Their Orientation? 200 Participants Reporting a Change from Homosexual to Heterosexual Orientation," Archives of Sexual Behavior 32 (2003): 403–17.
23 Ibid., 403 (abstract).
24 Kenneth Zucker, "The Politics and Science of Reparative Therapy," Archives of Sexual Behavior 32 (2003): 399.
25 A. Dean Byrd, Joseph Nicolosi, and Richard W. Potts, "Clients' Perceptions of How Reorientation Therapy and Self-Help Can Promote Changes in Sexual Orientation," Psychological Reports 102, 1 (2008): 3–28.
26 LeBlanc, 94.
27 "NARTH Mission Statement," About NARTH, National Association for Research and Therapy of Homosexuality, http://www.narth.com/menus/mission.html.
28 Hamer, quoted in Anastasia Toufexis, "New Evidence of a 'Gay Gene,'" Time, November 13, 1995, 95.
29 Sharon Begley, "How the Brain Rewires Itself," Time, January 29, 2007, 72.
30 Frank P. McMaster and Vivek. Kusumakar, "Hippocampal Volume in Early-Onset Depression," BMC Medicine 2, 2 (2004): 1–6.
31 Boldizar Czeh and Paul. J. Lucassen, "What Causes the Hippocampal Volume Decrease in Depression? Are Neurogenesis, Glial Changes, and Apoptosis Implicated?" European Archives of Psychiatry and Clinical Neuroscience 257, 5 (2007): 250–60.
32 "Are Politics in Your DNA?" The Scientist Daily e-mail newsletter, January 9, 2007. No author given in original article. Available through The Scientist, Magazine of the Life Sciences, http://www.the-scientist.com/register/.