TRENDS IN BEHAVIORAL GENETICS

EUGENICS REVISITED

by John Horgan, *senior writer*

Scientists are linking genes to a host of complex human disorders and traits, but just how valid—and useful—are these findings?

"How to Tell If Your Child's a Serial Killer!" That was the sound bite with which the television show *Donahue* sought to entice listeners February 25. On the program, a psychiatrist from the Rochester, N.Y., area noted that some men are born with not one Y chromosome but two. Double-Y men, the psychiatrist said, are "at special risk for antisocial, violent behavior." In fact, the psychiatrist had recently studied such a man. Although he had grown up in a "Norman Rockwell" setting, as an adult he had strangled at least 11 women and two children.

"It is not hysterical or overstating it," Phil Donahue told his horrified audience, "to say that we are moving toward the time when, quite literally, just as we can anticipate…genetic predispositions toward various physical diseases, we will also be able to pinpoint mental disorders which include aggression, antisocial behavior and the possibility of very serious criminal activity later on."

Eugenics is back in fashion. The message that genetics can explain, predict and even modify human behavior for the betterment of society is promulgated not just on sensationalistic talk shows but by our most prominent scientists. James D. Watson, co-discoverer of the double-helix structure of DNA and former head of the Human Genome Project, the massive effort to map our entire genetic endowment, said recently, "We used to think that our fate was in our stars. Now we know, in large part, that our fate is in our genes."

Daniel E. Koshland, Jr., a biologist at the University of California at Berkeley and editor of *Science,* the most influential peer-reviewed journal in the U.S., has declared in an editorial that the nature/nurture debate is "basically over," since scientists have shown that genes influence many aspects of human behavior. He has also contended that genetic research may help eliminate society's most intractable problems, including drug abuse, homelessness and, yes, violent crime.

Some studies cited to back this claim are remarkably similar to those conducted over a century ago by scientists such as Francis Galton, known as the father of eugenics. Just as the British polymath studied identical twins in order to show that "nature prevails enormously over nurture," so do modern researchers. But the primary reason behind the revival of eugenics is the astonishing successes of biologists in mapping and manipulating the human genome. Over the past decade, investigators have identified genes underlying such

NATURE OR NURTURE? Identical twins Paula and Nina Sossen were brought up together and share the same genes. Yet Paula (right)*, a graduate student at the University of Michigan, is heterosexual; Nina, a graphic designer in Madison, Wis., is a lesbian.*

"EERIE" PARALLELS between identical twins raised apart—such as Jerry Levey (*left*) and Mark Newman, who both became firefighters—are said to support genetic models of human behavior. Yet skeptics say the significance of such coincidences has been exaggerated.

crippling diseases as cystic fibrosis, muscular dystrophy and, this past spring, Huntington's disease. Given these advances, researchers say, it is only a matter of time before they can lay bare the genetic foundation of much more complex traits and disorders.

The political base for eugenics has also become considerably broader in recent years. Spokespersons for the mentally ill believe demonstrating the genetic basis of disorders such as schizophrenia and manic depression—and even alcoholism and drug addiction—will lead not only to better diagnoses and treatments but also to more compassion toward sufferers and their families. Some homosexuals believe society will become more tolerant toward them if it can be shown that sexual orientation is an innate, biological condition and not a matter of choice.

But critics contend that no good can come of bad science. Far from moving inexorably closer to its goals, they point out, the field of behavioral genetics is mired in the same problems that have always plagued it. Behavioral traits are extraordinarily difficult to define, and practically every claim of a genetic basis can also be explained as an environmental effect. "This has been a huge enterprise, and for the most part the work has been done shoddily. Even careful people get sucked into misinterpreting data," says Jonathan Beckwith, a geneticist at Harvard University. He adds, "There are social consequences to this."

The skeptics also accuse the media of having created an unrealistically optimistic view of the field. Richard C. Lewontin, a biologist at Harvard and a prominent critic of behavioral genetics, contends that the media generally give much more prominent coverage to dramatic reports—such as the discovery of an "alcoholism gene"—than to contradictory results or retractions. "Skepticism doesn't make the news," Lewontin says. "It only makes the news when you find a gene." The result is that spurious findings often become accepted by the public and even by so-called experts.

The claim that men with an extra Y chromosome are predisposed toward violence is a case in point. It stems from a survey in the 1960s that found more extra-Y men in prison than in the general population. Some researchers hypothesized that since the Y chromosome confers male attributes, men with an extra Y become hyperaggressive "supermales." Follow-up studies indicated that while extra-Y men tend to be taller than other men and score slightly lower on intelligence tests, they are otherwise normal. The National Academy of Sciences concluded in a report published this year that there is no evidence to support the link between the extra Y chromosome and violent behavior.

Minnesota Twins

No research in behavioral genetics has been more eagerly embraced by the press than the identical-twin studies done at the University of Minnesota. Thomas J. Bouchard, Jr., a psychologist, initiated them in the late 1970s, and since then they have been featured in the *Washington Post, Newsweek,* the *New York Times* and other publications worldwide as well as on television. *Science* has favorably described the Minnesota team's work in several news stories and in 1990 published a major article by the group.

The workers have studied more than 50 pairs of identical twins who were separated shortly after birth and raised in different households. The assumption is that any differences between identical twins, who share all each other's genes, are caused by the environment; similarities are attributed to their shared genes. The group estimates the relative contribution of genes to a given trait in a term called "heritability." A trait that stems entirely from genes, such as eye color, is defined as 100 percent heritable. Height is 90 percent heritable; that is, 90 percent of the variation in height is accounted for by genetic variation, and the other 10 percent is accounted for by diet and other environmental factors.

The Minnesota group has reported finding a strong genetic contribution to practically all the traits it has examined. Whereas most previous studies have estimated the heritability of intelligence (as defined by performance on intelligence tests) as roughly 50 percent, Bouchard and his colleagues arrived at a figure of 70 percent. They have also found a genetic component underlying such culturally defined traits as religiosity, political orientation (conservative versus liberal), job satisfaction, leisure-time interests and proneness to divorce. In fact, the group concluded in *Science,* "On multiple measures of personality and temperament…monozy-

gotic twins reared apart are about as similar as are monozygotic twins reared together." (Identical twins are called monozygotic because they stem from a single fertilized egg, or zygote.)

The researchers have buttressed their statistical findings with anecdotes about "eerie," "bewitching" and "remarkable" parallels between reunited twins. One case involved Oskar, who was raised as a Nazi in Czechoslovakia, and Jack, who was raised as a Jew in Trinidad. Both were reportedly wearing shirts with epaulets when they were reunited by the Minnesota group in 1979. They also both flushed the toilet before as well as after using it and enjoyed deliberately sneezing to startle people in elevators.

Some other celebrated cases involved two British women who wore seven rings and named their firstborn sons Richard Andrew and Andrew Richard; two men who both had been named Jim, named their pet dogs Toy, married women named Linda, divorced them and remarried women named Betty; and two men who had become firefighters and drank Budweiser beer.

Other twin researchers say the significance of these coincidences has been greatly exaggerated. Richard J. Rose of Indiana University, who is collaborating on a study of 16,000 pairs of twins in Finland, points out that "if you bring together strangers who were born on the same day in the same country and ask them to find similarities between them, you may find a lot of seemingly astounding coincidences."

Rose's collaborator, Jaakko Kaprio of the University of Helsinki, notes that the Minnesota twin studies may also be biased by their selection method. Whereas he and Rose gather data by combing birth registries and sending questionnaires to those identified as twins, the Minnesota group relies heavily on media coverage to recruit new twins. The twins then come to Minnesota for a week of study—and, often, further publicity. Twins who are "interested in publicity and willing to support it," Kaprio says, may be atypical. This self-selection effect, he adds, may explain why the Bouchard group's estimates of heritability tend to be higher than those of other studies.

One of the most outspoken critics of the Minnesota twin studies—and indeed all twin studies indicating high heritability of behavioral traits—is Leon J. Kamin, a psychologist at Northeastern University. In the 1970s Kamin helped to expose inconsistencies and possible fraud in studies of separated identical twins conducted by the British psychologist Cyril Burt during the previous two decades. Burt's conclusion that intelligence was mostly inherited had inspired various observers, notably Arthur R. Jensen, a psychologist at the University of California at Berkeley, to argue that socioeconomic stratification in the U.S. is largely a genetic phenomenon.

In his investigations of other twin studies, Kamin has shown that identical twins supposedly raised apart are often raised by members of their family or by unrelated families in the same neighborhood; some twins had extensive contact with each other while growing up. Kamin suspects the same may be true of some Minnesota twins. He notes, for example, that some news accounts suggested Oskar and Jack (the Nazi and the Jew) and the two British women wearing seven rings were reunited for the first time when they arrived in Minnesota to be studied by Bouchard. Actually, both pairs of twins had met previously. Kamin has repeatedly asked the Minnesota group for detailed case histories of its twins to determine whether it has underestimated contact and similarities in upbringing. "They've never responded," he says.

Kamin proposes that the Minnesota twins have particularly strong motives to downplay previous contacts and to exaggerate their similarities. They might want to please researchers, to attract more attention from the media or even to make money. In fact, some twins acquired agents and were paid for appearances on television. Jack and Oskar recently sold their life story to a film producer in Los Angeles (who says Robert Duvall is interested in the roles).

Even the Minnesota researchers caution against overinterpretation of their work. They agree with their critics that high heritability should not be equated with inevitability, since the environment can still drastically affect the expression of a gene. For example, the genetic disease phenylketonuria, which causes profound retardation, has a heritability of 100 percent. Yet eliminating the amino acid phenylalanine from the diet of affected persons prevents retardation from occurring.

Such warnings tend to be minimized in media coverage, however. Writers often make the same inference that Koshland did in an editorial in *Science:* "Better schools, a better environment, bet-

Behavioral Genetics: A Lack-of-Progress Report

CRIME: Family, twin and adoption studies have suggested a heritability of 0 to more than 50 percent for predisposition to crime. (Heritability represents the degree to which a trait stems from genetic factors.) In the 1960s researchers reported an association between an extra Y chromosome and violent crime in males. Follow-up studies found that association to be spurious.

MANIC DEPRESSION: Twin and family studies indicate heritability of 60 to 80 percent for susceptibility to manic depression. In 1987 two groups reported locating different genes linked to manic depression, one in Amish families and the other in Israeli families. Both reports have been retracted.

SCHIZOPHRENIA: Twin studies show heritability of 40 to 90 percent. In 1988 a group reported finding a gene linked to schizophrenia in British and Icelandic families. Other studies documented no linkage, and the initial claim has now been retracted.

ALCOHOLISM: Twin and adoption studies suggest heritability ranging from 0 to 60 percent. In 1990 a group claimed to link a gene—one that produces a receptor for the neurotransmitter dopamine—with alcoholism. A recent review of the evidence concluded it does not support a link.

INTELLIGENCE: Twin and adoption studies show a heritability of performance on intelligence tests of 20 to 80 percent. One group recently unveiled preliminary evidence for genetic markers for high intelligence (an IQ of 130 or higher). The study is unpublished.

HOMOSEXUALITY: In 1991 a researcher cited anatomic differences between the brains of heterosexual and homosexual males. Two recent twin studies have found a heritability of roughly 50 percent for predisposition to male or female homosexuality. These reports have been disputed. Another group claims to have preliminary evidence of genes linked to male homosexuality. The data have not been published.

ter counseling and better rehabilitation will help some individuals but not all." The prime minister of Singapore apparently reached the same conclusion. A decade ago he cited popular accounts of the Minnesota research in defending policies that encouraged middle-class Singaporeans to bear children and discouraged childbearing by the poor.

Smart Genes

Twin studies, of course, do not indicate which specific genes contribute to a trait. Early in the 1980s scientists began developing powerful ways to unearth that information. The techniques stem from the fact that certain stretches of human DNA, called polymorphisms, vary in a predictable way. If a polymorphism is consistently inherited together with a given trait—blue eyes, for example—then geneticists assume it either lies near a gene for that trait or actually is the gene. A polymorphism that merely lies near a gene is known as a marker.

In so-called linkage studies, investigators search for polymorphisms co-inherited with a trait in families unusually prone to the trait. In 1983 researchers used this method to find a marker linked to Huntington's disease, a crippling neurological disorder that usually strikes carriers in middle age and kills them within 10 years. Since then, the same technique has pinpointed genes for cystic fibrosis, muscular dystrophy and other diseases. In association studies, researchers compare the relative frequency of polymorphisms in two unrelated populations, one with the trait and one lacking it.

Workers are already using both methods to search for polymorphisms associated with intelligence, defined as the ability to score well on standardized intelligence tests. In 1991 Shelley D. Smith of the Boys Town National Institute for Communication Disorders in Children, in Omaha, and David W. Fulker of the University of Colorado identified polymorphisms associated with dyslexia in a linkage study of 19 families exhibiting high incidence of the reading disorder.

Two years ago Robert Plomin, a psychologist at Pennsylvania State University who has long been active in behavioral genetics, received a $600,000 grant from the National Institute of Child Health and Human Development to search for genes linked to high intelligence. Plomin is using the association method, which he says is more suited than the linkage technique to identifying genes whose contribution to a trait is relatively small. Plomin is studying a group of 64 schoolchildren 12 to 13 years old who fall into three groups: those who score approximately 130, 100 and 80 on intelligence tests.

Plomin has examined some 25 polymorphisms in each of these three groups, trying to determine whether any occur with greater frequency in the "bright" children. The polymorphisms have been linked to genes thought to have neurological effects. He has uncovered several markers that seem to occur more often in the highest-scoring children. He is now seeking to replicate his results in another group of 60 children; half score above 142 on intelligence tests, and half score less than 74 (yet have no obvious organic deficiencies). Plomin presented his preliminary findings at a meeting, titled "Origins and Development of High Ability," held in London in January.

At the same meeting, however, other workers offered evidence that intelligence tests are actually poor predictors of success in business, the arts or even advanced academic programs. Indeed, even Plomin seems ambivalent about the value of his research. He suggests that someday genetic information on the cognitive abilities of children might help teachers design lessons that are more suited to students' innate strengths and weaknesses.

But he also calls his approach "a fishing expedition," given that a large number of genes may contribute to intelligence. He thinks the heritability of intelligence is not 70 percent, as the Minnesota twin researchers have claimed, but 50 percent, which is the average finding of other studies, and at best he can only find a gene that accounts for a tiny part of variance in intelligence. "If you wanted to select on the basis of this, it would be of no use whatsoever," he remarks. These cautions did not prevent the *Sunday Telegraph,* a London newspaper, from announcing that Plo-

The Huntington's Disease Saga: A Cautionary Tale

The identification of the gene for Huntington's disease, which was announced in March, was hailed as one of the great success stories of modern genetics. Yet it provides some rather sobering lessons for researchers seeking genes linked to more complex human disorders and traits.

The story begins in the late 1970s, when workers developed novel techniques for identifying polymorphisms, sections of the human genome that come in two or more forms. Investigators realized that by finding polymorphisms linked—always and exclusively—to diseases, they could determine which chromosome the gene resides in. Researchers decided to test the polymorphism technique on Huntington's disease, a devastating neurological disorder that affects roughly one in 10,000 people. Scientists had known for more than a century that Huntington's was caused by a mutant, dominant gene. If one parent has the disease, his or her offspring have a 50 percent chance of inheriting it.

One of the leaders of the Huntington's effort was Nancy Wexler, a neuropsychologist at Columbia University whose mother had died of the disease and who therefore has a 50 percent chance of developing it herself. She and other researchers focused on a poor Venezuelan village whose inhabitants had an unusually high incidence of the disease. In 1983, through what has now become a legendary stroke of good fortune, they found a linkage with one of the first polymorphisms they tested. The linkage indicated that the gene for Huntington's disease was somewhere on chromosome 4.

The finding led quickly to a test for determining whether offspring of carriers—either in utero or already born—have inherited the gene itself. The test requires an analysis of blood samples from several members of a family known to carry the disease. Wexler herself has declined to say whether she has taken the test.

Researchers assumed that they would quickly identify the actual gene in chromosome 4 that causes Huntington's disease. Yet it took 10 years for six teams of workers from 10 institutions to find the gene. It is a so-called expanding gene, which for unknown reasons gains base pairs (the chemical "rungs" binding two strands of DNA) every time it is transmitted. The greater the expansion of the gene, researchers say, the earlier the onset of the disease. The search was complicated by the fact that workers had no physical clues about the course of the disease to guide them. Indeed, Wexler and others emphasize that they still have no idea how the gene actually causes the disease; treatments or cures may be years or decades away.

The most immediate impact of the new discovery will be the development of a better test for Huntington's, one that requires blood only from the person at risk

NANCY WEXLER helped to find the gene responsible for Huntington's disease by studying a population in Venezuela that has been ravaged by the disorder.

and not other family members. By measuring the length of the mutant gene, the test might also predict more accurately when carriers will show symptoms.

As difficult as it was to pinpoint the gene for Huntington's, it will be almost infinitely harder to discover genes for behavioral disorders, says Evan S. Balaban, a biologist at Harvard University. Unlike Huntington's disease, he notes, disorders such as schizophrenia and alcoholism cannot be unambiguously diagnosed. Furthermore, they stem not from a single dominant gene but from many genes acting in concert with environmental effects. If researchers do find a statistical association between certain genes and a trait, Balaban says, that knowledge may never be translated into useful therapies or tests. "What does it mean to have a 10 percent increased risk of alcoholism?" he asks.

min had found "evidence that geniuses are born not made."

Evan S. Balaban, a biologist at Harvard, thinks Plomin's fishing expedition is doomed to fail. He grants that there may well be a significant genetic component to intelligence (while insisting that studies by Bouchard and others have not demonstrated one). But he doubts whether investigators will ever uncover any specific genes related to high intelligence or "genius." "It is very rare to find genes that have a specific effect," he says. "For evolutionary reasons, this just doesn't happen very often."

The history of the search for markers associated with mental illness supports Balaban's view. Over the past few decades, studies of twins, families and adoptees have convinced most investigators that schizophrenia and manic depression are not caused by psychosocial factors—such as the notorious "schizophrenogenic mother" postulated by some Freudian psychiatrists—but by biological and genetic factors. After observing the dramatic success of linkage studies in the early 1980s, researchers immediately began using the technique to isolate polymorphic markers for mental illness. The potential value of such research was enormous, given that schizophrenia and manic depression each affect roughly one percent of the global population.

They seemed to have achieved their first great success in 1987. A group led by Janice A. Egeland of the University of Miami School of Medicine claimed it had linked a genetic marker on chromosome 11 to manic depression in an Amish population. That same year another team, led by Miron Baron of Columbia University, linked a marker on the X chromosome to manic depression in three Israeli families.

The media hailed these announcements as major breakthroughs. Far less attention was paid to the retractions that followed. A more extensive analysis of the Amish in 1989 by a group from the National Institute of Mental Health turned up no link between chromosome 11 and manic depression. This year Baron's team retracted its claim of linkage with the X chromosome after doing a new study of its Israeli families with more sophisticated markers and more extensive diagnoses.

Schizophrenic Results

Studies of schizophrenia have followed a remarkably similar course. In 1988 a group headed by Hugh M. D. Gurling of the University College, London, Medical School announced in *Nature* that it had found linkage in Icelandic and British families between genetic markers on chromosome 5 and schizophrenia. In the same issue, however, researchers led by Kenneth K. Kidd of Yale University reported seeing no such linkage in a Swedish family. Although Gurling defended his result as legitimate for several years, additional research has convinced him that it was probably a false positive. "The new families showed no linkage at all," he says.

These disappointments have highlighted the problems involved in using linkage to study mental illness. Neil Risch, a geneticist at Yale, points out that linkage analysis is ideal for studying diseases, such as Huntington's, that have distinct symptoms and are caused by a single dominant gene. Some researchers had hoped that at least certain subtypes of schizophrenia or manic depression might be single-gene disorders. Single-gene mutations are thought to cause variants of breast cancer and of Alzheimer's disease that run in families and are manifested much earlier than usual. But such diseases are rare, Risch says, because natural selection quickly winnows them out of the population, and no evidence exists for distinct subtypes of manic depression or schizophrenia.

Indeed, all the available evidence suggests that schizophrenia and manic depression are caused by at least several genes—each of which may exert only a tiny influence—acting in concert with environmental influences. Finding such genes with linkage analysis may not be impossible, Risch says, but it will be considerably more difficult than identifying genes that have a one-to-one correspondence to a trait. The difficulty is compounded by the fact that the diagnosis of mental illness is often subjective—all the more so when researchers are relying on family records or recollections.

Some experts now question whether genes play a significant role in mental illness. "Personally, I think we have overestimated the genetic component of schizophrenia," says E. Fuller Torrey, a psychiatrist at St. Elizabeth's Hospital in Washington, D.C. He argues that the evidence supporting genetic models can be explained by other biological factors, such as a virus that strikes in utero. The pattern of incidence of schizophrenia in families often resembles that of other viral diseases, such as polio. "Genes may just create a susceptibility to the virus," Torrey explains.

The Drink Link

Even Kidd, the Yale geneticist who has devoted his career to searching for genes linked to mental illness, acknowledges that "in a rigorous, technical, scientific sense, there is very little proof that schizophrenia, manic depression" and other psychiatric disorders have a genetic origin. "Virtually all the evidence supports a genetic explanation, but there are always other explanations, even if they are convoluted."

The evidence for a genetic basis for alcoholism is even more tentative than that for manic depression and schizophrenia. Although some studies discern a genetic component, especially in males, others have reached the opposite conclusion. Gurling, the University College investigator, found a decade ago that identical twins were slightly *more* likely to be discordant for alcoholism than fraternal twins. The drinking habits of some identical twins were strikingly different. "In some cases, one drank a few bottles a day, and the other didn't drink at all," Gurling says.

Nevertheless, in 1990 a group led by Kenneth Blum of the University of Texas Health Science Center at San Antonio announced it had discovered a genetic marker for alcoholism in an association study comparing 35 alcoholics with a control group of 35 nonalcoholics. A page-one story in the *New York Times* portrayed the research as a potential watershed in the diagnosis and treatment of alcoholism without mentioning the considerable skepticism aroused among other researchers.

The Blum group claimed that its marker, called the A1 allele, was associated with a gene, called the D2 gene, that codes for a receptor for the neurotransmitter dopamine. Skeptics noted that the A1 allele was actually some 10,000 base pairs from the dopamine-receptor gene and was not linked to any detectable variation in its expression.

Since the initial announcement by Blum, three papers, including an additional one by Blum's group, have presented more evidence of an association between the A1 allele and alcoholism. Six groups have found no such evidence (and received virtually no mention in the popular media).

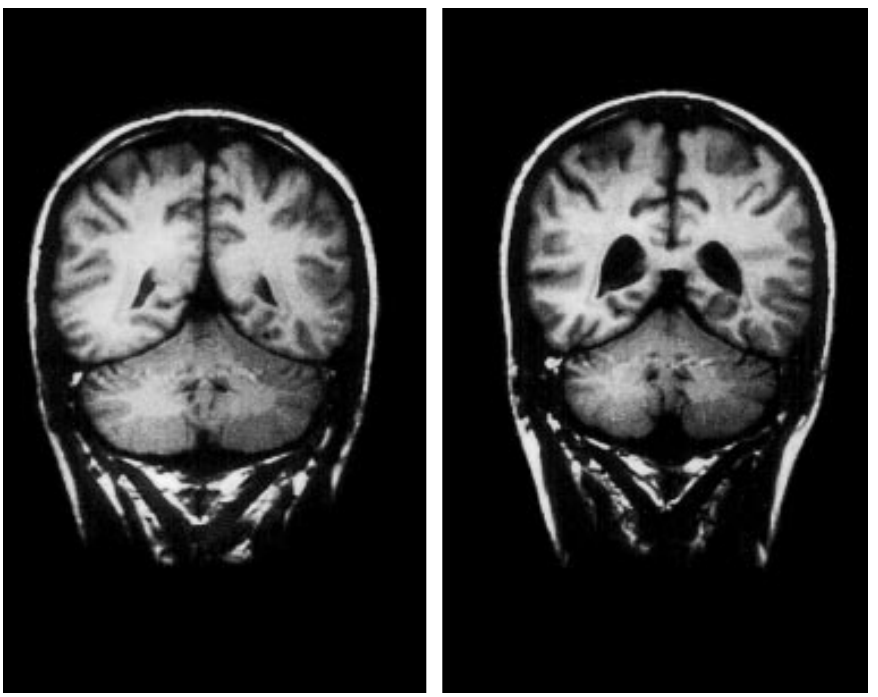
In April, Risch and Joel Gelernter of Yale and David Goldman of the National Institute on Alcohol Abuse and Alcoholism analyzed all these studies on the A1 allele in a paper in the *Journal of the American Medical Association*. They noted that if Blum's two studies are cast aside, the balance of the results shows no association between the D2 receptor and alcoholism, either in the disorder's milder or most severe forms. "We therefore conclude that no physiologically significant association" between the A1 allele and alcoholism has been proved, the group stated. "It's a dead issue," Risch says.

Gelernter and his colleagues point out that association studies are prone to spurious results if not properly controlled. They suggest that the positive findings of Blum and his colleagues may have derived from a failure to control for ethnic variation. The limited surveys done so far have shown that the incidence of the A1 allele varies wildly in different ethnic groups, ranging from 10 percent in certain Jewish groups to about 50 percent in Japanese.

Blum insists that the ethnic data, far from undermining his case, support it, since those groups with the highest prevalence of the A1 allele also exhibit the highest rates of "addictive behavior." He contends that the only reason the Japanese do not display higher rates of alcoholism is that many also carry a gene that prevents them from metabolizing alcohol. "They're pretty compulsive," explains Blum, who recently obtained a patent for a genetic test for alcoholism.

These arguments have been rejected even by Irving I. Gottesman of the University of Virginia, who is a strong defender of genetic models of human behavior. He considers the papers cited by Blum to support his case to be ambiguous and even contradictory. Some see an association only with alcoholism that leads to medical complications or even death; others discern no association with alcoholism but only with "polysubstance abuse," including cigarette smoking. "I think it is by and large garbage," Gottesman says of the alleged A1-alcoholism link.

By far the most controversial area of behavioral genetics is research on crime. Last fall complaints by civil-rights leaders and others led the National Institutes of Health to withdraw its funding from a meeting entitled "Genetic Factors in Crime: Findings, Uses and Implications." The conference brochure had noted the "apparent failure of environmental approaches to crime" and suggested that genetic research might yield methods for identifying and treating po-



BRAIN OF SCHIZOPHRENIC (*right*) appears different from the brain of his identical twin in these magnetic resonance images. Such findings suggest that factors that are biological but not genetic—such as viruses—may play a significant role in mental illness.

tential criminals—and particularly those prone to violence—at an early age.

Critics contend that such investigations inevitably suggest that blacks are predisposed to crime, given that blacks in the U.S. are six times more likely than whites to be arrested for a violent crime. In fact, some prominent scientists, notably Richard J. Herrnstein, a psychologist at Harvard, have made this assertion. Others reject this view but insist biological research on attributes linked to violent crime, such as aggression, may still have some value. "People who are unwilling to address genetic and biochemical factors are just putting their heads in the sand," says Goldman, the alcoholism expert. "It is not fair to say that just because there have been geneticists who have had a very narrow view of this in the past, we shouldn't explore this now."

In fact, investigations of the biology of violent crime continue, albeit quietly. Workers at City of Hope Hospital in Duarte, Calif., claim to have found an association between the A1 allele—the alleged alcoholism marker—and "criminal aggression." Last year a group led by Markus J. P. Kruesi of the University of Illinois at Chicago presented evidence of an association between low levels of the neurotransmitter serotonin and disruptive-behavior disorders in children. Kruesi concedes there is no way to determine whether the serotonin levels are genetically influenced. In fact, the serotonin levels might be an effect—a reaction to an environmental trauma—rather than a cause. "This might be a scar marker," he says.

One reason such research persists is that studies of families, twins and adoptees have suggested a genetic component to crime. Glenn D. Walters, a psychologist at the Federal Correctional Institution in Schuylkill, Pa., recently reviewed 38 of these studies, conducted from the 1930s to the present, in the journal *Criminology*. His meta-analysis turned up a small genetic effect, "but nothing to get excited about." He observes that "a lot of the research has not been very good" and that the more recent, better-designed studies tended to turn up less evidence. "I don't think we will find any biological markers for crime," he says. "We should put our resources elsewhere."

Gay Genes

The ostensible purpose of investigations of mental illness, alcoholism and even crime is to reduce their incidence. Scientists studying homosexuality have a different goal: simply to test whether homosexuality is innate, as many homosexuals have long professed. That claim was advanced by a report in *Science* in 1991 by Simon LeVay of the Salk Institute for Biological Studies in San Diego. LeVay has acknowledged both that he is gay and that he believes evidence of biological differences between homosexuals and heterosexuals will encourage tolerance toward gays.

LeVay, who recently left the Salk Institute to found the Institute of Gay and Lesbian Education, focused on a tiny neural structure in the hypothalamus, a region of the brain known to control sexual response. He measured this structure, called the interstitial nu-

"Better Breeding"

Fairly or not, modern genetics research is still haunted by the history of eugenics. "It offers a lot of cautionary lessons," says Daniel J. Kevles, a historian at the California Institute of Technology, who wrote the 1985 book *In the Name of Eugenics*. The British scientist Francis Galton, cousin to Charles Darwin, first proposed that human society could be improved "through better breeding" in 1865 in an article entitled "Hereditary Talent and Character." He coined the term "eugenics," from the Greek for "good birth," in 1883.

Galton's proposal had broad appeal. The American sexual libertarian John Humphrey Noyes bent eugenics into an ingenious argument for polygamy. "While the good man will be limited by his conscience to what the law allows," Noyes said, "the bad man, free from moral check, will distribute his seed beyond the legal limit."

A more serious advocate was the biologist Charles B. Davenport, founder of Cold Spring Harbor Laboratory and of the Eugenics Record Office, which gathered information on thousands of American families for genetic research. After demonstrating the heritability of eye, skin and hair color, Davenport went on to "prove" the heritability of traits such as "pauperism," criminality and "feeble-mindedness." In one monograph, published in 1919, he asserted that the ability to be a naval officer is an inherited trait, composed of subtraits for thalassophilia, or love of the sea, and hyperkineticism, or wanderlust. Noting the paucity of female naval officers, Davenport concluded that the trait is unique to males.

Beginning in the 1920s the American Eugenics Society, founded by Davenport and others, sponsored "Fitter Families Contests" at state fairs around the U.S. Just as cows and sheep were appraised by judges at the fairs, so were human entrants (such as the family shown above at the 1925 Texas State Fair). Less amusingly, eugenicists helped to persuade more than 20 U.S. states to authorize sterilization of men and women in prisons and mental hospitals, and they urged the federal government to restrict the immigration of "undesirable" races.

No nation, of course, practiced eugenics as enthusiastically as Nazi Germany, whose program culminated in "euthanasia" ("good death") of the mentally and physically disabled as well as Jews, Gypsies, Catholics and others. As revelations of these atrocities spread after World War II, popular support for eugenics programs waned in the U.S. and elsewhere.

cleus, in autopsies of the brains of 19 homosexual males, 16 heterosexual males and six heterosexual women. LeVay found that the interstitial nucleus was almost twice as large in the heterosexual males as in the homosexual males or in the women. He postulated that the interstitial nucleus "is large in individuals oriented toward women"—whether male or female.

Of course, LeVay's finding only addresses anatomic differences, not necessarily genetic ones. Various other researchers have tried to establish that homosexuality is not just biological in its origin—caused, perhaps, by hormonal influences in utero—but also genetic. Some have sought evidence in experiments with rats and other animals. A group headed by Angela Pattatucci of the National Cancer Institute is studying a strain of male fruit flies—which wags have dubbed either "fruity" or "fruitless"—that court other males.

In December 1991 J. Michael Bailey of Northwestern University and Richard C. Pillard of Boston University announced they had uncovered evidence of a genetic basis for male homosexuality in humans. They studied 161 gay men, each of whom had at least one identical or fraternal twin or adopted brother. The researchers determined that 52 percent of the identical twins were both homosexual, as compared with 22 percent of the fraternal twins and 11 percent of the adopted brothers.

Bailey and Pillard derived similar results in a study of lesbians published this year in the *Archives of General Psychiatry*. They compared 147 gay women with identical or fraternal twins or adopted sisters: 48 percent of the identical twins were both gay, versus 16 percent of the fraternal twins (who share only half each other's genes) and 6 percent of the adopted sisters. "Both male and female sexual orientation appeared to be influenced by genetic factors," Bailey and Pillard concluded.

This conclusion has disturbed some of Bailey and Pillard's own subjects. "I have major questions about the validity of some of the assumptions they are making," says Nina Sossen, a gay woman living in Madison, Wis., whose identical twin is heterosexual. Her doubts are shared by William Byne, a psychiatrist at Columbia University. He notes that in their study of male homosexuality Bailey and Pillard found more concordance between unrelated, adopted brothers than related (but non-twin) brothers. The high concordance of the male and female identical twins, moreover, may stem from the fact that such twins are often dressed alike and treated alike—indeed, they are often mistaken for each other—by family members as well as by others.

"The increased concordance for homosexuality among the identical twins could be entirely accounted for by the increased similarity of their developmental experiences," Byne says. "In my opinion, the major finding of that study is that 48 percent of identical twins who were reared together were discordant for sexual orientation."

Byne also criticizes LeVay's conclusion that homosexuality must be biological—although not necessarily genetic—because the brains of male homosexuals resemble the brains of women. That assumption, Byne points out, rests on still another assumption, that there are significant anatomic differences between heterosexual male and female brains. But to date, there have been no replicable studies showing such sexual dimorphism.

Byne notes that he has been suspected of having an antigay motive. Two reviewers of an article he recently wrote criticizing homosexuality research accused him of having a "right-wing agenda," he says. He has also been contacted by conservative groups hoping he will speak out against the admittance of homosexuals to the military. He emphasizes that he supports gay rights and thinks homosexuality, whatever its cause, is not a "choice." He adds that genetic models of behavior are just as likely to foment bigotry as to quell it.

"Hierarchy of Worthlessness"

Despite the skepticism of Byne and others, at least one group, led by Dean Hamer of the National Cancer Institute, is searching not merely for anatomic or biochemical differences in homosexuals but for genetic markers. Hamer has done a linkage study of numerous small families, each of which has at least two gay brothers. He says his study has turned up some tentative findings, and he plans to submit his results soon. Hamer's colleague Pattatucci is planning a similar study of lesbians.

What purpose will be served by pinpointing genes linked to homosexuality? In an information sheet for prospective participants in his study, Hamer expresses the hope that his research may "improve understanding between people with different sexual orientations." He adds, "This study is not aimed at developing methods to alter either heterosexual or homosexual orientation, and the results of the study will not allow sexual orientation to be determined by a blood test or amniocentesis."

Yet even Pillard, who is gay and applauds Hamer's work, admits to some concern over the potential uses of a genetic marker for homosexuality. He notes that some parents might choose to abort embryos carrying such a marker. Male and female homosexuals might then retaliate, he says, by conceiving children and aborting fetuses that lacked such a gene.

Balaban, the Harvard biologist, thinks the possible dangers of such research—assuming it is successful—outweigh any benefits. Indeed, he sees behavioral genetics as a "hierarchy of worthlessness," with twin studies at the bottom and linkage studies of mental illness at the top. The best researchers can hope for is to find, say, a gene associated with a slightly elevated risk of schizophrenia. Such information is more likely to lead to discrimination by insurance companies and employers than to therapeutic benefits, Balaban warns.

His colleague Lewontin agrees. In the 1970s, he recalls, insurance companies began requiring black customers to take tests for sickle cell anemia, a genetic disease that primarily affects blacks. Those who refused to take the test or who tested positive were denied coverage. "I feel that this research is a substitute for what is really hard—finding out how to change social conditions," Lewontin remarks. "I think it's the wrong direction for research, given that we have a finite amount of resources."

Paul R. Billings, a geneticist at the California Pacific Medical Center, shares some of these concerns. He agrees that twin studies seem to be inherently ambiguous, and he urges researchers seeking markers for homosexuality to consider what a conservative government—led by Patrick Buchanan, for example—might allow to be done with such information. But he believes some aspects of behavioral genetics, particularly searches for genes underlying mental illness, are worth pursuing.

In an article published in the British journal *Social Science and Medicine* last year, Billings and two other scientists offered some constructive criticism for the field. Researchers engaged in association and linkage studies should establish "strict criteria as to what would constitute meaningful data." Both scientists and the press should emphasize the limitations of such studies, "especially when the mechanism of how a gene acts on a behavior is not known." Billings and his colleagues strive to end their article on a positive note. "Despite the shortcomings of other studies," they say, "there is relatively good evidence for a site on the X chromosome which is associated with [manic depression] in some families." This finding was retracted earlier this year.