sect control process based on the use of antiallatotropic compounds should represent an insect-specific approach to safe and selective insecticides.

Summary

Two simple chromenes with anti-JH activity have been isolated and identified from the bedding plant *Ageratum houstonianum*. By contact and fumigation these compounds induce precocious metamorphosis and sterilization in several hemipteran species of insects. Certain holometabolous species are sterilized, forced into diapause, or both. Each of these biological actions is equivalent to removal of the corpora allata, which produce the JH's, and is reversible by treatment with exogenous JH. Thus, the action of these compounds is to stop the production or depress the titer of the JH's. To our knowledge, this is the first discovery of anti-JH, and we hope it will guide the way to the emergence of a fourth generation of safe and insect-specific pesticides.

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28. Reaction of an appropriate phenol with excess dimethylacrylic acid in polyphosphoric acid (PPA) on the steam bath gives the crystalline chromanone in nearly quantitative yield. The chromanone is reduced with lithium aluminum hydride in ether and then stirred briefly with 4*N* HCl to effect dehydration to the chromene. Overall yield is about 80 percent.

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Criminality in XYY and XXY Men

The elevated crime rate of XYY males is not related to aggression. It may be related to low intelligence.

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Few issues in behavior genetics have received more public and scientific attention than that given to the possible role of an extra Y chromosome in human aggression. Soon after the literature began to suggest an elevated frequency of the XYY genotype among inmates of institutions for criminals and delinquents, interest in this issue had a meteoric rise; and it has been sustained ever since. This happened for several reasons. Stories about a few men who had or were presumed to have an extra Y chromosome and who had committed serious crimes were given prominent attention in the press, suggesting the intriguing idea that the single Y chromosome normally found in males contributes to "aggressive tendencies" in that sex and that an extra Y carries these tendencies beyond their usual bounds. Reports of antisocial behavior in XYY men, often based on a single case, soon began to appear in the scientific literature (*1*) and were taken as evidence of an XYY-aggression linkage. The serious moral and legal implications of such a linkage attracted the interest of social scientists and legal groups to the XYY phenomenon (*2*), and students of genetics and psychology saw in it, as Lederberg (*3*) has said, "one of the most tangible leads for connecting genetic constitution with behavior in man."

A number of studies have supported the earlier finding of an elevated frequency of cases with an XYY complement among men in institutions, particularly in penal-mental institutions (*4*–

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8). At the same time, these studies have not provided clear evidence of whether or not there exists an "XYY syndrome" of which antisocial behavior is a prominent component. Neither have they provided a definitive answer to the question of why men with an extra Y chromosome are at higher risk for institutionalization than XY men. For the sake of identifying the kind of research that is needed to clarify these issues, it is worth reviewing the main limitations of the studies on which our present information about XYY men is based, and also the lacunae in our knowledge.

First, the search for XYY men has often been conducted in selected groups presumed to be likely to contain them, such as institutionalized men and tall men. Second, a number of reports now in the literature are based on observations of a single case or just a few cases (*1*). Third, many studies of XYY's have not included control XY's; and in those that did, comparisons were often made with knowledge of the genotype of the individuals being evaluated (*5*). The control groups used have varied in nature, and comparison of results from different studies has therefore been difficult. There has been a dearth of psychological, somatic, and social data obtained for the same individual XYY men. Finally, there do not yet exist adequate prevalence data for the XYY genotype in the general adult population with which the XYY yield of any particular study may be compared. Though incidence data on neonates are available for a fairly large number of subjects, incidence studies of neonates are still few, and there are potential problems in the practice of pooling highly variable incidence findings from studies with populations that are quite different from each other or whose characteristics have not been adequately specified.

With the evidence in its present state, it is not surprising to find divergent views about the support it provides for a link between XYY and aggression, as for example in the contradictory conclusions reached in recent reviews of the XYY literature (*4–7*). Whatever the interpretation of the available evidence, however, most investigators concerned with the XYY problem are agreed on the research that is now required to determine whether the XYY complement has any behavioral or social consequences. What is needed, ideally, is an ascertainment study of a large population unselected with regard to institutionalization or height, and a comparison of the XYY cases identified with control XY's in psychological, somatic, social, and developmental characteristics, the evaluation of these characteristics in the two groups being made according to a double-blind procedure.

The study we undertook, done in Denmark because of the excellent social records kept there, was designed to meet as many of these specifications as our financial resources allowed. It was already evident at the time we undertook the study that XYY's tend to be very tall (*9*). As a way of maximizing the chances of obtaining a sufficient sample of XYY's for intensive individual study, we decided to do chromosomal determinations of all men in the top 15 percent of the height distribution of our Danish male population. A sampling of men in the bottom 85 percent would also have been desirable, but the probability of finding XYY's among shorter men is so small as to make an effective study of shorter XYY's too expensive to conduct.

A first aim of this research project was to determine whether XYY's from the total general population have an elevated crime rate. A second aim, if an elevated crime rate appeared, was to identify intervening variables that may mediate the relation between an extra Y chromosome and increased antisocial behavior. Three variables of particular interest are aggressiveness, intelligence, and height.

A common interpretation of the finding that XYY's tend to be overrepresented in criminal institutions is that aggressiveness is an intervening variable. In this view, an extra Y chromosome increases aggressive tendencies and these, in turn, lead to increased criminal behavior. If this interpretation is correct, we may expect crimes committed by XYY men to be aggressive in nature, involving assaultive actions against other persons. We designate this the aggression hypothesis.

Concerning intelligence the reasoning is as follows: In common with most genetic aberrations, an extra Y in the male chromosomal complement is likely to have an adverse effect on development. Among possible dysfunctions, of particular interest for the XYY question is dysfunction in the intellectual domain. There is some evidence, although it is hardly consistent, of an intellectual impairment in XYY men (*7, 10, 11*). Intellectual impairment may contribute to antisocial behavior. It seems plausible also that when individuals with impaired intellectual functioning commit crimes, they are more likely to be apprehended than are criminals of normal intelligence. This conception of intelligence as an intervening variable, mediating the relation between the presence of an extra Y chromosome and antisocial behavior, may be designated the intellectual-dysfunction hypothesis.

The extreme height of XYY's may facilitate aggressive acts on their part. In addition, it may cause them to be perceived by others as dangerous, with the possible consequence that they are more likely than shorter men to be suspected of crimes, to be pursued and apprehended, and, when tried, to be convicted. The view that tallness may serve as an intervening variable we designate the height hypothesis.

Because XXY's (Klinefelter males) also tend to be tall, we could expect our case-finding effort in the top 15 percent height group to identify a number of XXY's as well as XYY's. Most studies of XXY's have suffered from essentially the same limitations as those mentioned earlier for studies of XYY's; a study of XXY's is therefore of value in its own right. In addition, there is some evidence that XXY's also appear in institutions with disproportionate frequency. This raises the possibility that any sex chromosome aberration in males, and not particularly an extra Y, may be associated with increased risk of institutionalization (*5*). Comparison of XYY's and XXY's may help to assess this possibility.

This article deals with the results of the case-finding study among tall men and with the evidence obtained to this point from the social records available for the XYY and XXY men who were found. An intensive individual study is now being conducted with these men and their controls (*12*).

Case-Finding Procedure

The population from which we sampled consisted of all male Danish citizens born to women who were residents of the municipality of Copenhagen, Denmark, between 1 January 1944 and 31 December 1947, inclusive. Not only did Copenhagen afford a very large source population, but available demographic data indicated that most men born in the city at that time would still be living there. The parish records, in which all births are registered, were used to identify the males born there in the chosen period. They numbered 31,436. The *folkeregister* (the Danish national register) provided current addresses and other information.

Information about the height of these men was obtained from draft board records where possible. The use of the 4-year period between 1944 and 1947 to

define the target population provided us with a group of men who were at least 26 years old, the age by which Danish men are required to report to their draft boards for a physical examination, at which time their heights are recorded. For the small group of men who for some reason had never visited their draft boards, height data were obtained from other sources, such as institutions and the civil defense. In the very few cases where such sources were not available, cards were addressed directly to the men themselves requesting that they send us their heights.

By these methods, a group was composed consisting of 28,884 men who were still alive when the study began and for whom height information could be obtained. This group numbered 2552 fewer cases than the target population of 31,436 Copenhagen-born men. Of these 2552 cases 1791 were dead; 37 could not be traced for height determination; 21 could not be located at all in the *folkeregister* (probably for such reasons as name changes, death at birth, address change at birth), and 703 had emigrated and no record of their height was available. Of the 664 emigrants for whom we were able to determine age at emigration, 85.2 percent had emigrated before age 18, so that it is probable that in many of those cases the decisions about emigration were made by parents.

A cutoff point of 184 centimeters was used in composing the tall group in which the search for sex chromosome anomalies was to be conducted. The resulting group consisted of 4591 men, the top 15.9 percent of the height distribution in the total group of 28,884. Deaths reduced the tall group by 33 during the case-finding period, leaving a total of 4558 men to be searched for sex chromosome anomalies. An attempt was made to visit the homes of all 4558 for the purpose of obtaining blood samples and buccal smears to be used in determining chromosomal constitution.

Before home visiting began, members of the study staff were interviewed by the news media. These interviews provided an opportunity to publicize the purpose and nature of the study, with the result that most of the men who were asked to participate in the study had already heard of it when first approached. The initial individual contact was made by a letter, which mentioned the nature of the study and indicated that someone from the study staff would visit at a specified time. If the subject expected not to be at home at that time, he was asked to return a card on which he could suggest an alternative time. Men not found at home, and who had not asked for an alternative date, were subsequently revisited, up to a total of 14 times in the most extreme instance.

When the subject was seen, he was shown a newspaper clipping reporting the interview with our staff members and any questions he had were answered. The subject was also assured that his anonymity would be maintained. He was then asked whether he would be willing to give a buccal smear and, if he agreed, whether he would be willing to give a few drops of blood from an earlobe as well. The home visitor also asked the subject to fill out a questionnaire, and told him that at a later time he might be asked to participate further in the study. As the case-finding effort progressed, various methods were adopted to facilitate and encourage participation, such as setting up a station at one of the centrally located hospitals in Copenhagen to which the men were invited to come during a wide range of daytime and evening hours, and offering small financial inducements.

The 4139 men for whom sex chromosome determinations were made constituted 90.8 percent of the starting group of 4558 living tall men (*13*). Of the 419 unexamined cases, 174 men declined to participate; 138 men emigrated in the course of the study or were sailors and away from Denmark; 25 were destitute men without identifiable homes; and 82 men, on repeated visits, were not found at the official addresses listed for them in the *folkeregister* (*14*). Some characteristics of these cases, and of the 174 men who declined to take part, are given below.

The buccal smears and blood samples were taken to the Chromosomal Laboratory of Rigshospitalet, in Copenhagen, for analysis. The buccal smears were stained with hematoxylin for the detection of X chromatin (*15*) and with quinacrine dihydrochloride for the detection of Y chromatin (*16*). The peripheral blood was treated by a micromethod modification (*17*) of the method of Moorhead *et al.* (*18*). Chromosome preparations were stained conventionally with orcein and by the method of Seabright (*19*) for G-banding and the method of Caspersson *et al.* (*20*) for Q-banding and identification of the Y chromosome (*21*).

Documentary Data

A variety of records was available for almost all the men in the study. The present report is limited to data from these records for five variables: height, convictions for criminal offenses, level of intellectual functioning as indicated by scores on an army selection test and by educational attainment, and parental social class at the time of the subject's birth.

The sources of information about height have already been described.

The source of data on convictions for criminal offenses was penal certificates (*straffeattest*) obtained from penal registers (*strafferegistrene*) maintained in the offices of local police chiefs. These certificates are extracts of court records of trials and cover all violations of the penal code that resulted in convictions. Offenses in the Danish penal code include such acts as these, among others: forgery, intentional arson, sexual offenses, premeditated homicide, attempted homicide, manslaughter, assault and battery, housebreaking, larceny, receiving stolen goods, and damage to property belonging to others. The penal certificates contain highly reliable information concerning the section of the penal law violated and the penalty imposed. A subject was considered to have a criminal record if he was convicted of one or more criminal offenses.

For evaluation of level of intellectual functioning, two kinds of measures were used. One was scores from the test employed in screening army recruits for intelligence, the *Børge Priens Prøver* (BPP), available from the draft-board records. Because the BPP was constructed as a screening device, it covers only a limited number of cognitive dimensions. The BPP scores are accordingly only rough indicators of intellectual level. The scores could not be obtained for some men; most frequent in this group were men who had never taken the test and men whose records were not available because they were in the army.

The second measure of intellectual functioning was educational level achieved. In Denmark examinations are given at the end of the 9th, 10th, and 13th years of schooling. From the available social records it was possible to determine which, if any, of these examinations was passed. For our "educational index" subjects who passed no examination were given a score of 0, and those who passed the first-, second-, and third-level examinations were given scores of 1, 2, and 3, respectively. It should be noted that the maximum rating assigned was 3 regardless of how many additional years of education the individual may have had (*22*). In a very small number of cases information needed for determining the educational index could not be obtained.

Table 1. Crime rates and mean values for background variables of XY's, XYY's, and XXY's. Significance level pertains to comparison with the control group (XY) using a two-sided test. For criminality rate an exact binomial test was used; for all other variables a *t*-test was used.

Group	Criminality		Army selection test (BPP)			Educational index			Parental SES			Height		
	Rate (%)	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	*N*
XY	9.3	4096	43.7	11.4	3759	1.55	1.18	4084	3.7	1.7	4058	187.1	3.0	4096
XYY	41.7*	12	29.7†	8.2	12	0.58*	0.86	12	3.2	1.5	12	190.8†	4.6	12
XXY	18.8	16	28.4†	14.1	16	0.81‡	0.88	16	4.2	1.8	16	189.8†	3.6	16

*$P < .01$. †$P < .001$. ‡$P < .05$.

Parental socioeconomic status (SES) was classified primarily according to father's occupation at the time of the subject's birth. In a small number of cases the father or his occupation was not known; in some of these instances mother's occupation was known and was used instead. A seven-point SES classification was used, modified from a nine-point classification devised by Svalastoga (*23*).

Frequency of XYY's and XXY's and of Criminals Among Them

Among the 4139 men for whom sex chromosome determinations were made, 12 XYY's and 16 XXY's were identified. These frequencies represent prevalence rates of 2.9/1000 and 3.9/1000, respectively. Thirteen men were identified as XY's with other chromosomal anomalies. The remainder, all identified as having the normal XY complement, constituted the control group (*13*).

A search in the penal registers showed that 41.7 percent of the XYY's (5 of 12 cases), 18.8 percent of the XXY's (3 of 16 cases), and 9.3 percent of the XY controls had been convicted of one or more criminal offenses (Table 1). The difference between the percentages for the XYY's and the XY controls is statistically significant ($P < .01$, exact binomial test). The rate for the XXY's is somewhat higher than the rate for the XY controls, but that difference is not significant; neither is the difference in rates between the XYY's and XXY's.

A first approach to evaluation of the aggression hypothesis was to examine the nature of the crimes of which the five XYY's had been convicted (Table 2). Their offenses were not particularly acts of aggression against people. Only in case 2 do we find an instance of such an act. The difference between the XYY's and XY's in percentage of cases with one or more convictions for crimes of violence against another person—8.4 percent (one man out of the 12) versus 1.8 percent (71 out of 4096)—is not statistically significant (one-tailed exact binomial test). If we compare only those who had criminal convictions, the XYY's and XY's are again very similar in percentage of convictions that involved crimes of violence against a person (20.0 and 19.4 percent, respectively). These data provide no evidence that XYY's are more likely to commit crimes of violence than XY's (*24*).

The generally mild penalties imposed on the convicted XYY's (Table 2) indicate that their crimes were not extremely serious. By far the most severe sentence was imprisonment for somewhat less than a year (*25*), imposed on case 2. Also suggesting that the XYY's with records of criminal convictions are not serious criminals is the fact that for one (case 5) the last conviction was 10 years ago, for another (case 3) 5 years ago, and for a third (case 7) 5 years ago. Of the remaining two XYY's, both of whom had extensive criminal records, one (case 12) is mentally retarded. In fact, all five of these XYY's have BPP's below the average of 43.7 (Table 1) for the XY controls, all but one of them well below that average.

There is a suggestion in our data that several of the crimes of XYY's were committed under circumstances which made detection of the crime and apprehension of the perpetrator particularly likely. Thus, one man sent in a false alarm directly to the police about a presumably serious traffic accident. Another man committed many burglaries of homes while the owners were on the premises.

Turning to the three XXY's with criminal records (Table 3), we find that one, in the single crime he committed, assaulted his wife in an extremely brutal way, while under the influence of alcohol. The other two had short periods of juvenile delinquency, and the penalties imposed on them were slight. The last conviction of one was 7 years ago, of the other 10 years ago. All three have BPP scores well below the XY average. Finally, in percentage of cases with one or more convictions for crimes of violence against another person, the difference between the XXY's and the XY controls (6.2 percent versus 1.8 percent) was not statistically significant (one-tailed exact binomial test) (*26*).

As a first step toward evaluating the intellectual-dysfunction hypothesis, the intellectual level of each of the two proband groups was compared to that of the XY controls, scores on the army selection test (BPP) and the educational index being used for this purpose. For both kinds of measures the mean for the control group (Table 1) is significantly higher than the means for either the XYY or the XXY group ($P < .05$ in each instance, *t*-test). The means for the two proband groups are not significantly different from each other. (It should be noted that the two indicators of intellectual level we used are highly related; for the control group the correlation between BPP scores and educational index is .59 [$P < .00005$, *t*-test].)

Having established that the proband groups are significantly lower than the XY controls on both measures of intellectual level, we next examine the relation of these measures to criminality. Our data show, first, that BPP scores are significantly related to frequency of occurrence of registered crimes leading to convictions. In the control group, men with no record of such crimes had a mean BPP of 44.5, whereas those with one or more such crimes had a mean BPP of 35.5 ($P < .00001$, *t*-test). The educational index showed a similar relation to criminality (means of 1.62 for noncriminals and 0.74 for criminals [$P < .00001$, *t*-test]).

Overall, then, the pattern of results on intellectual functioning provides support for the intellectual-dysfunction hypothesis.

Both proband groups are significantly taller than the XY control groups (Table 1). Within the restricted height range of the XY's, however, noncriminals (mean height 187.1 centimeters) were slightly taller ($P = .0013$, *t*-test) than criminals (mean height, 186.7 centimeters), a finding contrary to the hypothesis that tallness

may mediate the relation between the extra Y chromosome and the likelihood of criminal convictions.

In neither proband group is parental SES significantly different from that of the XY control group (Table 1). As expected, parental SES was significantly higher ($P < .0001$, t-test) for noncriminals (mean = 3.71) than for criminals (mean = 3.02).

Criminal Rates After Adjustment for Background Variables

We next compare the criminal rates of XYY's and XXY's with that of XY's equivalent to them in level of intellectual functioning, height, and parental SES. Only subjects for whom complete data were available are included (all 12 XYY's, all 16 XXY's, and 3738 XY's). The analysis consists of three stages: the first step establishes the probability that an XY with a particular set of values for the background variables is a criminal; the second step establishes for each XYY or XXY the probability that he would be a criminal if he were an XY with his background-variable values; the third step compares the observed frequency of criminals in the proband group with the frequency predicted in the second step.

To permit use of existing programs for the log-linear analysis we employed, it was necessary to make the two continuous variables, BPP and height, categorical. Past work (*27*) with simpler problems suggests that five or six categories often provide a very good representation of a continuous variable. Because height showed a very low relation to criminality in our sample of tall men, we used only five categories for height. The finding that BPP is strongly related to criminality, particularly within the restricted range of low BPP scores, made it advisable to use more categories for BPP. Accordingly, seven categories were employed for this variable.

In the 980-cell contingency table representing all combinations of the $5 \times 7 \times 4 \times 7$ categories for height, BPP, educational index, and parental SES, respectively, let us consider a particular cell. If $n_1 + n_2$ of the 3738 XY's (n_1 being criminals and n_2 noncriminals) fall in that cell, the proportion $n_1/(n_1 + n_2)$ gives a good estimate of the probability that a new XY in that cell will be a criminal, provided the value of $n_1 + n_2$ is large. In many of the 980 cells, however, both n_1 and n_2 are small; in fact in 376 cells both n_1 and n_2 are zero. But it is not necessary to consider each cell independently. Instead, a model may be built for these probabilities which lets us "borrow strength" from similar cells. Critical in building such a model is the definition of similarity. The method we used in constructing a model for our contingency table has been described by Bishop, Fienberg, and Holland (*28*). This method is based on log-linear models that are

Table 2. Nature of offenses of XYY's convicted on one or more criminal charges.

Case No. 2

This man is a chronic criminal who, since early adolescence, has spent 9 of 15 years in youth prisons and regular prisons. By far his most frequent criminal offense, especially in his youth, has been theft or attempted theft of a motor vehicle. Other charges included burglary, embezzlement, and procuring for prostitution. On a single occasion he committed a mild form of violence against an unoffending person; for this together with one case of burglary he received a sentence of around three-quarters of a year. This aggressive act was an isolated incident in a long period of chronic criminality. Except for this act, and the charge of procuring, all his nearly 50 offenses were against property, predominantly larceny and burglary. His single most severe penalty was somewhat less than a year in prison. Most of his crimes were committed in the company of other persons (BPP, 27).

Case No. 3

This man committed two thefts, one in late adolescence, the second in his early 20's. The penalties for both were mild—a small fine for the first, and less than 3 months in prison for the second. His last offense was 7 years ago (BPP, 37).

Case No. 5

This man committed two petty offenses as a young adult, within a short time of each other (one the theft of a motor-assisted cycle, the other a petty civil offense), for which the penalties were detentions of approximately 2 weeks and less than 2 weeks, respectively. His last offense was committed 10 years ago (BPP, 28).

Case No. 7

This man committed his only criminal offenses in his 20's, within a short period of time: falsely reporting a traffic accident to the police and causing a small fire. On both occasions he was intoxicated. The penalty was probation. His last offense was committed 5 years ago (BPP, 25).

Case No. 12

This man was under welfare care as a child and has spent only three to four of the last 20 years outside of institutions for the retarded. He is an episodic criminal. When very young he committed arson. Later his crimes included theft of motor vehicles, burglary, larceny, and embezzlement. His more than 90 registered offenses were all against property, mostly theft and burglary. For crimes committed while he was out of an institution, the penalty imposed was placement in an institution for the mentally retarded. For crimes committed while he was in such an institution—once theft of a bicycle, another time theft of a quantity of beverage— he was continued in the institution (BPP, 18).*

*Since this man was mentally retarded and spent many years in an institution for the retarded, he was not given a BPP at the draft board. The BPP of 18 was estimated by a stepwise linear regression, using a double cross-validity design, from the correlation between BPP scores and scores for the Wechsler Adult Intelligence Scale for the men in the individual case study.

Table 3. Nature of offenses of XXY's convicted on one or more criminal charges.

Case No. 17

This man's only criminal offense, committed when he was well into his 20's, was that he attacked his wife in an exceptionally brutal way, without any provocation from her. This happened twice, within a very short interval, while he was under the influence of liquor. For this he was imprisoned for somewhat more than a year (BPP, 26).

Case No. 25

The criminal career of this man consisted of two offenses: the first, in late adolescence, a theft of edibles from a food store, for which he was placed on probation, the second the theft of a motor vehicle, for which he was given less than 3 weeks of simple detention. Both crimes were committed in company with others. The last occurred 7 years ago (BPP, 11).

Case No. 27

This man had a short period of juvenile delinquency. His offenses included attempted theft and theft of a motor vehicle and a bicycle, burglary, and theft from a vending machine. On his first offense, in early adolescence, the charge was withdrawn and he was put under the care of child welfare authorities. His two other penalties consisted of withdrawal of charge on payment of a fine. Several of his offenses were committed in company with another person. The last occurred 10 years ago (BPP, 16).

analogous to the usual linear models (that is, regression and analysis of variance). The difference between them is that log-linear models are appropriate for categorical dependent variables (such as criminal/noncriminal), whereas linear models are appropriate for continuous dependent variables. For those familiar with linear models, it is appropriate to think of the analyses performed here as if they were regressions, with criminality taken as the dependent variable and BPP, height, parental SES, and educational index as independent variables, even though in fact the computations required for the log-linear analyses are quite different. We present here only the final results of our analyses.

For the 3738 tall XY's used in the analyses, the proportion of criminals in each of the 980 cells of the contingency table can be very accurately predicted from a model with only six parameters: a grand mean parameter, reflecting the overall level of criminality in the population; one regression parameter reflecting the tendency of criminality to increase as parental SES decreases; two regression parameters (for linear and quadratic components) reflecting the tendency of criminality to increase more and more rapidly as educational index decreases; and two regression parameters (for linear and quadratic components) reflecting the tendency of criminality to increase more and more rapidly as BPP decreases. The absence of two kinds of parameters should be noted. There are no parameters relating criminality to height, indicating that the presence of the components for parental SES, BPP, and educational index there is no additional effect attributable to height. Also, there are no parameters reflecting interactions among these variables, because their effects on criminality are independent.

The fit of this six-parameter model to the full contingency table is extremely good. Globally, the adequacy of the fit is indicated by the log-likelihood ratio criterion divided by its degrees of freedom. (In fact, this corresponds to an F test in the analysis of variance or multiple regression. Under the null hypothesis that the model reflects the true state of nature the ratio should be about unity, and it should be larger than unity if the model does not fit.) This criterion for the six-parameter model and our four-way table is 491.65/(980-376-6) or 0.82. The significance test of the adequacy of the model follows from the fact that under the six-parameter model the log-likelihood criterion is distributed as χ^2 with 598 degrees of freedom. Hence, the significance level for the test of the adequacy of the six-parameter model, as opposed to the alternative one-parameter-per-cell model, is $P > .99$. The six-parameter model thus cannot be rejected.

Locally, the fit of the six-parameter model is also very good. In individual cells with reasonably large $n_1 + n_2$ values, the estimated probability is close to the observed proportion; and in collections of cells in which the total $n_1 + n_2$ is large, the estimated probability is also close to the observed proportion.

We now apply this model to the XYY and XXY probands. Tables 4 and 5 show the educational index, parental SES, BPP, and height of each proband and whether or not he had a criminal record. Also shown is the probability, predicted from the six-parameter model, that he would be a criminal if he were an XY. The last column gives the estimated standard errors of the estimated proportions. Since the sample size for the model (3738) is very large compared to the number of parameters used, these estimated standard errors are probably very accurate. It should be noted that for both XYY's and XXY's, the standard error is less than 16 percent of the estimated proportion except in one case (an XXY), in which it is 19 percent. Hence, the predicted probabilities are very accurate, particularly for the XYY's and may be considered exact for our purposes.

The number of criminals to be expected in each of the proband groups if

Table 4. Individual XYY's. Values of background variables, observed criminality (1 = record of one or more convictions, 0 = no record), and probability of criminality predicted from the XY model.

Case No.	Educational index	Parental SES	BPP	Height (cm)	Criminality		
					Observed	Predicted	
						Probability	Standard error
1	0	2	41	201	0	.14	.013
2	0	1	27	188	1	.21	.018
3	2	6	37	194	1	.05	.008
4	1	3	23	188	0	.22	.026
5	0	3	28	191	1	.18	.012
6	0	3	19	191	0	.27	.022
7	0	4	25	193	1	.16	.013
8	2	4	44	192	0	.05	.005
9	0	4	24	187	0	.25	.024
10	2	2	37	184	0	.07	.009
11	0	5	33	196	0	.15	.016
12	0	1	18*	185	1	.31	.027
					$N = 5$	$N = 2.06$	

*Estimated (see Table 2, footnote).

Table 5. Individual XXY's. Values of background variables, observed criminality (1 = record of one or more convictions, 0 = no record), and probability of criminality predicted from the XY model.

Case No.	Educational index	Parental SES	BPP	Height (cm)	Criminality		
					Observed	Predicted	
						Probability	Standard error
13	1	4	27	188	0	.13	.014
14	2	5	47	185	0	.04	.005
15	0	4	35	191	0	.16	.013
16	0	3	23	184	0	.27	.022
17	1	3	26	187	1	.14	.014
18	2	4	50	195	0	.05	.005
19	0	5	14	192	0	.37	.058
20	2	7	49	186	0	.04	.006
21	0	3	14	188	0	.41	.054
22	0	5	9	197	0	.37	.057
23	1	1	39	191	0	.12	.015
24	2	7	33	188	0	.07	.013
25	0	4	11	190	1	.39	.055
26	0	1	15	195	0	.31	.027
27	0	4	16	190	1	.25	.024
28	2	7	46	189	0	.04	.006
					$N = 3$	$N = 3.16$	

their crime rate was the same as that of XY's equivalent in parental SES, educational index, BPP, and height is given by the sum of the predicted probabilities (column 7 of each table); the observed number of criminals is given by the sum of the 0 and 1 values (column 6).

The result of adjustments for BPP, parental SES, and educational index indicates that these variables account for some of the raw difference in criminality between the XYY and XY groups. However, an elevation in crime rate among the XYY's remains ($P = .037$; one-sided exact binomial test) even after these adjustments are made, the observed and the predicted number of criminals in the XYY group being 5 and 2.06, respectively. The XXY's are not significantly different in criminality from the XY group ($P = .41$) after the adjustment for background variables is made, as is shown by the agreement between observed and predicted number of criminals (3 versus 3.16).

Discussion and Conclusions

A first question to consider is the validity of the ascertainment data of 2.9/1000 XYY's and 3.9/1000 XXY's among the tall men sampled in the study.

For XYY's other prevalence data are available from two recent large-scale studies of tall men, but comparison with ours is made difficult by differences in source populations and in the heights taken as cutoff points. In one of these studies (*29*) the prevalence rate for the tall normal men sampled appears to be a good deal higher than our own, whereas in the other (*11*) it seems not very different.

Studies of the incidence of XYY in neonates are still few in number and their results variable. Two recent reviews have tentatively suggested an incidence rate of about 1/1000 live-born males (*6, 7*), another (*5*) a rate in the range of 1/1500 to 1/3000. On the basis of these values the expected number of XYY's in our total population at birth would be about 9 to about 29. For several reasons it is difficult to determine the proportion of these who would be likely to be present in the tall segment we sampled in adulthood. There are uncertainties about the rate of attrition through death among XYY's (*30*). There are also uncertainties about how many XYY's there might be among the unexamined tall men in our study (those who refused to participate, who emigrated, or who could not be located) (*31*) and among the shorter men we did not examine. Though our obtained frequency falls well within the range estimated from neonatal studies, given all the limitations and uncertainties involved in generating those estimates the correspondence must be interpreted with caution. At the same time, there seem to be no grounds in these figures for suspecting a bias in our prevalence findings.

An evaluation of our XXY prevalence figure of 3.9/1000 presents the same problems as our XYY data: there are no satisfactory prevalence data for comparison, and incidence data are not yet adequate.

As to the rate of criminality, our finding is consistent with past findings from studies of institutionalized populations, in that the XYY's we identified had a higher mean rate of criminal convictions than the XY controls.

With regard to the possible correlates of the elevated XYY crime rate, the hypothesis we considered that height may be an intervening variable was not confirmed. In fact, within our tall XY group height showed a small but statistically significant negative relation to criminality.

On the other hand, the evidence from this study is consistent with a second hypothesis we considered, the intellectual-dysfunction hypothesis. The XYY's had an appreciably lower mean on the BPP, the army selection intelligence test, than did the XY's, and they also had a substantially lower mean on the related index of educational level attained, although some of the XYY's were within or not far out of the normal range on these variables. Moreover, in our XY sample criminality showed a substantial relation to both measures of level of intellectual functioning.

While intellectual functioning is thus clearly implicated as an important mediating variable, we cannot at this time say whether it is the only factor involved. When the two intelligence indicators were controlled, along with parental SES and height, in order to determine how these variables account for the observed XYY-XY difference in crime rate, an elevation in the XYY crime rate remained, though the difference was reduced. However, the BPP is not a comprehensive test of intelligence. It is possible that there are areas of cognitive dysfunction in XYY's that it does not tap and that a more comprehensive battery of cognitive tests would increase the explanatory power of the intellectual-dysfunction hypothesis (*32*).

In evaluating that hypothesis it is important to recall that the crime data we used were derived from records of individuals who were actually apprehended. People of lower intelligence may be less adept at escaping detection and so be likely to have a higher representation in a classificatory system based on registered crimes. The elevated crime rate found in our XYY group may therefore reflect a higher detection rate rather than simply a higher rate of commission of crimes.

It should be stressed that finding a relation between the presence of an extra Y chromosome and impaired intellectual functioning does not mean that the Y chromosome is ordinarily implicated in intellectual functioning and that a specific genetic basis for intelligence has thereby been established. That is no more true than would be the conclusion that, because trisomy 21 is associated with the markedly impaired intellectual functioning found in Down's syndrome, autosome 21 must make a direct genetic contribution to ordinary intellectual development. Chromosomes and genes exert their influence on development in concert; altering any one of them may accordingly affect the overall organization of the individual's genetic material, with consequences beyond the specific contribution each component may make individually. The potentially serious consequences of altering the organization of genetic material is reflected in the finding that chromosomal abnormalities are evident in about half of all spontaneous abortions in the first trimester of pregnancy, the period when such abortions are most frequent (*33*). In the case of the XYY complement, as in the case of Down's syndrome, it seems more plausible that the intellectual deficit found is one manifestation of altered ontogenetic development, resulting from a change in overall organization of genetic material, than that the particular chromosome involved (the Y chromosome or autosome 21) is directly implicated in ordinary intellectual functioning. A finding that has already emerged from the individual case studies we are conducting of the XYY's and the XY controls seems consistent with the view that the aberrant XYY complement may have broad adverse developmental consequences. In waking electroencephalograms (EEG's) the XYY's showed a significantly lower average frequency of alpha rhythm than matched XY controls (*34*). Slower EEG frequencies are normally predominant at an earlier age (*35*); our finding can therefore be viewed as suggesting a developmental lag.

The third hypothesis we examined, the aggression hypothesis, received little support in an examination of the criminal records of the XYY's. Among all offenses committed by XYY's there was

only a single instance of an aggressive act against another person; and in that case the aggression was not severe. Thus the frequency of crimes of violence against another person was not statistically significantly higher in the XYY's than in the XY's. The elevated crime rate in our XYY sample reflects an elevated rate of property offenses. This picture is in keeping with results of previous studies, most of which have also found that XYY's are not more likely to commit crimes against people than are XY's (*5*). The infrequency of violent criminal acts among our XYY's is in line as well with the observation that XYY's show less aggressive behavior while in prison than do XY prisoners (*36*). Also consistent is our finding that XYY's were no more likely to decline to participate in this study than XY's. The aggression hypothesis cannot be ruled out by the analyses done thus far, but the evidence from the personality evaluations and the social-developmental histories in the individual case studies now being analyzed will allow a further and more direct assessment of that hypothesis.

We did not examine shorter XYY's in this study, but such men appear to be uncommon in institutions, even when ascertainment has been done with men unselected for height. Further, a recent study by Owen (*37*), based on the entire group of approximately 28,000 men who served as the source population for this study, has shown a slight inverse relation between height and criminal offenses. Thus height differences would not explain why short XYY's should appear less frequently in institutions than tall ones. Whether they do not appear because they are uncommon or because they do not commit detectable crimes, with regard to aggression shorter XYY's need be of no greater concern to society than the general run of men.

In addition to the variables of height, intellectual functioning, and aggression thus far examined as possible mediators in the relation between the XYY complement and an elevated crime rate, other variables are being considered in the individual case studies. These include characteristics of endocrine, neurological, and neuropsychological functioning.

The picture of the XXY's that has emerged to this point is in most ways similar to that of the XYY's. The XXY's showed a somewhat elevated crime rate compared to the XY's, but below that of the XYY's. The difference in crime rate between the XXY's and XYY's was not statistically significant. Though the XXY crime rate was slightly higher than that of the XY's, the difference was not statistically significant and the elevation disappeared when background variables were controlled. As to aggression, only one of the XXY's was convicted for an act of aggression, which was severe in nature. The XXY's were not significantly different from the XY's in frequency of crimes of violence against other persons. The XXY evidence thus does not provide any more impressive support for the aggression hypothesis than the XYY evidence does. With regard to intelligence, the XXY's, like the XYY's, had a substantially lower mean BPP and mean intellectual index than XY's did. The similarities between the XYY's and the XXY's suggest that, with regard to the characteristics considered thus far, the consequences of an extra Y chromosome may not be specific to that chromosomal aberration but may result from an extra X chromosome as well.

The data from the documentary records we have examined speak on society's legitimate concern about aggression among XYY and XXY men. No evidence has been found that men with either of these sex chromosome complements are especially aggressive. Because such men do not appear to contribute particularly to society's problem with aggressive crimes, their identification would not serve to ameliorate this problem.

References and Notes

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8. In view of institutional variations in admissions policies, not always clearly specified in the published reports, it is difficult to judge whether the tendency of XYY men to appear more frequently in penal-mental than in straight penal institutions reflects the involvement of a mental aspect as well as a penal aspect. No clear tendency toward higher representation of XYY's in mental institutions has been found; however, studies of such institutions have been few.
9. This has been shown both by height data from XYY ascertainment studies of unselected male populations [for example, D. J. Bartlett, W. P. Hurley, C. R. Brand, E. W. Poole, *Nature (London)* **219**, 351 (1968); B. F. Crandall, R. E. Carrel, R. S. Sparkes, *J. Pediat.* **80**, 62 (1972); L. E. DeBault, E. Johnston, P. Loeffelholz, *Dis. Nerv. Syst.* **33**, 590 (1972); E. G. Hook and D.-S. Kim, *Science* **172**, 284 (1971); P. A. Jacobs, M. Brunton, M. M. Melville, R. P. Brittain, W. F. McClemont, *Nature (London)* **208**, 1351 (1965); P. A. Jacobs, W. H. Price, S. Richmond, R. A. W. Ratcliff, *J. Med. Genet.* **8**, 49 (1971); J. Nielsen, *Br. J. Psychiatry* **119**, 503 (1971); A. M. Vianna, O. Frota-Pessoa, M. F. Lion, L. Decourt, *J. Med. Genet.* **9**, 165 (1972)]; and by studies which compared the height of XYY's to that of their siblings and parents (*7*, p. 222).
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12. Subjects in the individual case study are the XYY's and XXY's identified in the case-finding study described below, and two XY controls for each. Both controls are matched to the proband in height, age, and parental social class, and one is matched as well in intellectual level, as judged from scores on an army selection test. The tests given these subjects include a battery, approximately 16 hours in duration, of cognitive tests, personality tests, an interview, and physical, neurological, and neuropsychological examinations.
13. The identity of two of the sampled cases found to be XY's was lost to us in our records and could not be considered in the data analysis.
14. It is likely that many of these 82 men had moved in with friends and did not register the move as an official change of residence.
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21. A more detailed account of the chromosomal studies is given in J. Philip, C. Lundsteen, D. Owen, K. Hirschhorn, *Am. J. Hum. Genet.*, in press.
22. Not a single one of the XYY's or XXY's reached the 13-year examination, but a number of the XY controls did and may have gone on for additional education.
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25. As an aid to maintaining anonymity of the cases and yet conveying the essence of their criminal records, approximate rather than actual values of penalties (as in this instance) and ages are given in the text and in Table 2.
26. Our case-finding procedures provided an opportunity to obtain some additional evidence on real-life social behavior of XYY's and XXY's. As noted, repeated visits were paid, when necessary, to the homes of men from whom we were seeking buccal smears and blood samples. It is reasonable to speculate that men who required many visits before contact was made with them, under circumstances where the visit was expected and the opportunity given to propose an alternative time, were thereby showing a lack of cooperativeness. The mean number of home visits required to obtain a specimen was not significantly different between the XY controls and the XYY's or XXY's. Being at home or not seems to be related to marital status. A comparison of randomly selected samples of 150 men found at home on the first visit and 150 men not at home showed that in the first group 35 percent were single and 65 percent were married, whereas in the second group 60 percent were single and 40 percent married.

    In the individual case study, the XYY's and XXY's were again not significantly different from their controls in frequency of refusals to participate on the first invitation.
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30. There is some suggestion in our data on reasons for draft-board rejection that XYY's may be

vulnerable to somatic disorders, so that a correction factor derived from attrition data for the general population may not be appropriate for XYY's. The draft-board rejection data are not considered in detail here because of some ambiguities in the rejection classification used. Even if somatic difficulties are more common among XYY's, however, this in itself is probably not a contributing factor to their elevated frequency of criminal offenses. In our XY's a χ^2 test showed that the difference in frequency of criminal offenses between men rejected by their draft boards for health reasons (9.8 percent) and men not rejected on such grounds (12.4 percent) was not significant.

31. This question deserves particular attention because some of the subgroups in the unexamined sample have unusually high crime rates, as might be expected. The rates were 17.2 percent for men who declined to participate in the study, 17.4 percent for those who emigrated or were away at sea; 44.0 percent for the destitute men; and 31.7 percent for those who were not living at their address of record. The differences between these values and the 9.3 percent rate of the tall XY men examined are all statistically significant (χ^2, $P < .003$). If XYY's do tend to have higher crime rates, then according to these data XYY prevalence rates may be higher in the unexamined group than in the examined group. The number of unexamined tall men is relatively small, however. Further, if we apply to the unexamined group the finding for the examined group of a 1.3 percent XYY rate among all tall men with criminal convictions, then the probability is that among the 97 men with one or more criminal convictions in the unexamined tall group there is only one XYY. Because the crime rate of the unexamined group may understate the case, and because of uncertainties about some of the extrapolations made, this pattern of results cannot of course be taken as definitive.
32. In fact, in our individual case study we do have data from a wider assortment of cognitive tests for the probands and their matched XY controls which indicate that this may be true. These data suggest that more of the difference in rate of criminality between the XYY's and the XY's might have been accounted for had they been tested for an additional cognitive factor, figure fluency (FF) [R. B. Ekstrom, J. W. French, H. H. Harman, *Technical Report No. 8*, Office of Naval Research contract N 00014-71-C-0117, HR 150 329 (1975)]. A test of the FF factor was included in the battery used in the individual case study, but this factor is not well represented in the BPP, as is shown by a low, nonsignificant correlation of .28 between scores from the test of this factor and BPP scores. After adjusting for BPP and other background variables by the analysis of covariance, we find FF means of 32.5, 24.0, and 26.0 for XY's, XYY's, and XXY's, respectively. The F test for difference of means is significant at the .05 level. Especially significant ($P = .02$, two-tailed) is the t-test for the difference between the XYY adjusted mean and the XY adjusted mean, indicating that the average scores of XYY's on FF are lower even with BPP and the other background variables controlled. Furthermore, among the 49 XY controls the 8 men with records of convictions for one or more criminal offenses had a mean FF score of 29.0, while the mean for the 41 noncriminal XY's was 36.0 ($P < .05$, one-tailed t-test).
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38. This review was supported by grants MH 23975 and MH 628 from the National Institute of Mental Health. For advice at different points in the conception and conduct of the study, in analyses of the data, and in the preparation of this article we are grateful to L. L. Cavalli-Sforza, P. Holland, J. Lederberg, R. Schiavi, S. A. Shah, and A. Theilgaard. We are indebted to the Danish Ministry of Justice for making available the criminal records that were used in this article.

NEWS AND COMMENT

Breast Cancer: Second Thoughts About Routine Mammography

The auditorium of the National Institutes of Health (NIH) has been redecorated recently, its once "institutional pale" walls now covered with a fabric of vivid Chinese red. A subtle but perceptible glare makes you blink a couple of times as your eyes adjust to the startling light.

On the afternoon of 29 July, there was in that auditorium an event as startling as the surroundings. The director of the National Cancer Institute (NCI) was standing on a stage before an assembly of some 400 female NIH employees, asking them what he should do about a controversial breast cancer screening program.

At issue was the use of mammography (x-rays of the breast) as a tool for detecting cancer in asymptomatic women between the ages of 35 and 49. The NCI, in collaboration with the American Cancer Society (ACS), supports breast screening programs at 27 centers throughout the United States. During the past 4 years, some 270,000 women have had one or more breast x-rays and numbers of experts have pronounced mammography an invaluable technique for finding breast tumors while they are still small enough to cure.

That happy assessment of mammography was challenged recently by a panel of scientists who were appointed by the NCI itself to assess the benefits of breast x-rays versus the risks. Led by epidemiologist Lester Breslow, dean of the School of Public Health at the University of California at Los Angeles, that panel saw more evidence of risk than of benefit when it comes to younger women and, with no equivocation, called for "Immediate cessation of routine mammography for screening women under 50 years of age."

However, interpretation of the available data is very much a matter of judgment. So far, NCI director Frank J. Rauscher, Jr., who must decide whether to accept the Breslow recommendation or not, is not sure what course to take. He calls the data "frankly confusing," and said as much to the women of NIH. "I said in my memo [calling this meeting] that 'I need your help,' and I do," Rauscher declared in his opening remarks.

For those who are so used to the all-knowing physician telling an uncomprehending but compliant patient what to do—the doctor as God—the sight of the NCI director, standing in that bright red room, asking so-called "ordinary" women to contribute their two cents worth to a difficult decision was something extraordinary.

The script for the unprecedented meeting was simple. Rauscher, a Ph.D., and NCI deputy director Guy R. Newell, an M.D., would tell the women all the reasons they had for continuing the screening program in its present form and all the reasons for modifying it, which would mean calling a halt to routine mammograms for asymptomatic women who are younger than 50. There would be questions from the floor (which, as often as not, were answered, "We just don't know.") Then, the women could fill in a questionnaire, reporting whether, on the basis of what they had heard, they would or would not have a mammogram, or whether they were too confused to decide.

This was not meant to be scientific decision-making by plebiscite. Rauscher made it clear that the women's views would simply be one of many "inputs" to a decision that is his responsibility, but he also made it plain that he asked because he really wanted to hear. This was no pro forma concession to public participation and many of the women present, including those who found the whole thing terribly confusing, agreed with one participant who said, "I think everyone appreciates the fact that we were being taken into the equation."