largely responsible for demonstrating that nuclei in the doubly "magic number" region of ^{208}Pb are remarkably in agreement with shell model theory.

The early experiments have also initiated a whole new set of more sophisticated experiments (some of which I have briefly alluded to above) which promise to keep many physicists busy for a long time to come. A particularly interesting series of experiments are those being performed (*15*) at Duke University with high-resolution proton beams. This work shows the highly detailed nature of analogue resonances, that is, as coherent superpositions of many complicated compound states yielding a beautifully modulated wave train, the modulation being observed only in conventional experiments with poor-resolution proton beams. Similarly, nuclear theorists have been led to vastly improve their interpretation of, and computational techniques for, both nuclear reactions and nuclear structure in order to meet the more stringent tests provided by such experiments.

Perhaps a lesson can be learned from the historical development of the isospin concept. In the past the belief that $\mathbf{T} \cdot \mathbf{T}$ would not significantly commute with the dynamical Hamiltonian so that isospin would not be conserved sufficiently well enough certainly delayed the nuclear travels of isospin into the realm of heavy nuclei. Hopefully the same mistake will not occur in the future for other approximate symmetries of nature.

References and Notes

1. W. Heisenberg, *Z. Phys.* **77**, 1 (1932).
2. G. Breit and E. Feenberg, *Phys. Rev.* **50**, 850 (1936); B. Cassen and E. U. Condon, *ibid.*, p. 846.
3. E. P. Wigner, *Proc. Robert A. Welch Found. Conf. Chem. Res.* **1**, 67 (1958).
4. J. D. Anderson, C. Wong, J. W. McClure, *Phys. Rev.* **126**, 2170 (1962).
5. J. D. Fox, C. F. Moore, D. Robson, *Phys. Rev. Lett.* **12**, 198 (1964).
6. J. B. French and M. H. MacFarlane, *Nucl. Phys.* **26**, 168 (1961).
7. S. B. Treiman and S. Weinberg, *Phys. Rev.* **116**, 465 (1959).
8. E. M. Henley, in *Isospin in Nuclear Physics*, D. H. Wilkinson, Ed. (North-Holland, Amsterdam, 1969), p. 51.
9. A. M. Lane and J. M. Soper, *Nucl. Phys.* **37**, 663 (1962).
10. A. M. Lane, *ibid.* **35**, 676 (1962).
11. C. F. Moore, P. Richard, C. E. Watson, D. Robson, J. D. Fox, *Phys. Rev.* **141**, 1166 (1966).
12. A. I. Yavin, R. A. Hoffswell, T. M. Noweir, in *Proceedings of the International Conference on Isobaric Spin in Nuclear Physics*, J. D. Fox and D. Robson, Eds. (Academic Press, New York, 1966), p. 584.
13. G. Vourvopoulos and J. D. Fox, *Phys. Rev.* **177**, 1558 (1969).
14. R. Sherr, B. F. Bayman, E. Rost, M. E. Rickey, C. G. Hoot, *ibid.* **139**, B1272 (1965).
15. G. A. Keyworth, G. C. Kyker, E. G. Bilpuch, H. W. Newson, *Nucl. Phys.* **89**, 590 (1966).

16. Supported in part by NSF grant GP-15855.

Behavioral Implications of the Human XYY Genotype

Ernest B. Hook

The significance of the XYY chromosome pattern in the human male is still the subject of considerable controversy. Despite the apparent high prevalence in some studies of socially deviant individuals, negative reports have also appeared, and instances of apparently well-adjusted XYY individuals have been published. Some have questioned the existence of any link whatsoever with antisocial behavior.

Three of the outstanding questions concerning the XYY human genotype are thus: (i) Is an XYY male significantly more likely than an XY male to be found in settings for antisocial deviant individuals? (ii) If not, then how has the present controversy arisen; but if so, then what is the nature and extent of the association between the XYY genotype and the tendency to such placement? (iii) What is the magnitude of the risk for an XYY individual, specifically a newborn, of eventually manifesting antisocial behavior compared to that for an XY individual born to similar circumstances?

The author is a member of the Birth Defects Institute of the New York State Department of Health, Albany, New York 12208, and is also affiliated with the department of pediatrics, Albany Medical College of Union University.

Evidence for an Association with Deviant Behavior

Delinquent individuals may be segregated by society into a number of possible settings, not all of which may be appropriate for the behavior displayed, but which at least remove the individual from the community at large. For the discussion below I define as "mental" a setting for individuals who are retarded, disturbed, psychotic, alcoholic, or epileptic but which is not otherwise characterized; as "penal" a setting where there is some stated or implicit restriction on freedom because of punitive or security requirements; and as "mental-penal" a setting which meets both criteria. Examples of penal settings are general prisons and schools for juvenile delinquents and the like. Examples of mental-penal settings are hospitals for criminally insane and security wings in hospitals for the retarded. The populations of all three groups may overlap because admissions criteria are loosely applied, but in the initial analysis I consider these as separate types of settings. Furthermore, for the purposes of this review the terms "deviant antisocial behavior" or "deviance" are defined as that behavior which leads to or increases the likelihood of placement in a mental-penal or penal setting in a particular jurisdiction. This is not to imply that all of those in such settings have been placed there appropriately, or conversely.

Whereas a large number of institutionalized populations in different countries have been studied, only in Scotland has there been also a considerable study of "normal" groups for comparison (see Tables 1 and 2). Jacobs and her coworkers group detected 5 XYY's in 3500 consecutive male infants or 0.14 percent and no XYY's in 2040 "normal" adult males studied for a variety of reasons (*1, 2*). In contrast, in their original study in the wing for mentally retarded men in Carstairs maximum security hospital, 7 of 197 or 3.6 percent were XYY (*3*). Subsequent data from the same institution (*2, 4*) and one other mental-penal setting in Scotland (*2*) also yielded rates higher than the observed rate for Scottish newborns

and "normal" adults (Table 3) (*5*). In contrast, in Scottish groups which were either penal or mental, but not both, the rates have been much lower, and in fact none were markedly greater than that in newborns, with the possible exception of that in "approved schools" (see Tables 4 and 5).

There have been a number of studies of mental-penal groups in other countries, but the data are not as extensive on "normals" and newborns for comparison (see Tables 1 and 2). This raises the question as to what figures may be taken as a baseline. The pooled frequency to date in various studies on newborns (Table 1) is about 1 in 975 or 0.10 percent, whereas the rates in individual studies range from zero to about 1/250 (0.4 percent). In view of the small numbers involved in single studies, this variation may be due to sampling fluctuation about a true population mean of close to 1 in 1000. For the comparisons below, however, I take the maximum observed rate, 0.4 percent, for a baseline, so that the extent of the increase of XYY's in institutions is likely to be underestimated, probably by a factor of 4 (*6*).

Since the original series of Jacobs and her co-workers established that XYY's tend to be considerably taller than the XY's in custody, some workers have limited their investigations to tall individuals. Unfortunately, because of the sampling bias or limited data provided, the results of only some can be used in deciding whether there is an increase in the number of XYY's in the entire institution. But at least some conclusions are possible where (i) a low rate of XYY's has been found in the tall males studied, suggesting a negative outcome, or (ii) the number of XYY's actually found divided by the total number of males in the entire institution is greater than the baseline comparison rate, indicating a positive result. If the total number of patients in a setting from which a height truncated (tall) sample is taken is specified, the outcome could be positive, indeterminate, or negative. But if the total number is unknown only, an indeterminate or negative conclusion is possible. To correct for this, those reports that necessarily exclude a positive outcome are not considered in some of the tabulations below.

If the first Carstairs report is excluded (*3*, *5*), there are 35 subsequent studies of mental-penal settings to date of which I am aware (Tables 3 and 6) (*7–17*). In 21 the rates of XYY's are greater than background (that is, positive), in 7 the rates are lower (negative), and in 7 no decision is possible. The totals are 21 positive, 5 negative, and 1 indeterminate if those studies that necessarily exclude positive conclusions are not considered. The likelihood that this or a stronger trend in these studies occurred by chance alone is very small (*18*).

In those 20 studies which were not height restricted and for which exact data are provided, again excluding (*3*), the pooled frequency is 72 out of 3813 or 1.89 percent, the median of the 20 rates is 2.05 percent, and the mean is 2.05 percent. A point estimate of 2 percent thus appears not unreasonable for most mental-penal settings of the type represented in Table 3 (*19*). This figure is five times the maximum background rate of 0.4 percent used for comparison and about 20 times the pooled newborn rate of 0.10 percent. All of these settings are in Europe,

Table 1. Frequency of XYY and other sex chromosome abnormalities in newborn male populations.

Location	Reference	Population*	No. studied	XYY	XXY	Other
New Haven	(*39*)	Consecutive infants	2184	3	4	0
Boston 1	(*42, 100*)	Phenotypically normal infants, not in high risk category	1908	0	5	0
Boston 2	(*42*)	Consecutive newborns (clinic population)	1032	0	4	0
Boston 3	(*42*)	Consecutive newborns (clinic and private population)	4703	3	4	†
London (Ontario)	(*101*)	Consecutive newborns	1066	4	1	0
Toronto 1	(*102*)	Unselected newborns	1014	3	0	XXY/XY‡
Winnipeg	(*103*)	Consecutive newborns	3468	1	2	0
Edinburgh (U.K.)	(*1*)	Consecutive newborns	3496	5	3	XX male
Pittsburgh	(*104*)	Random sample of newborns	517	2	2	XXYY
Denver	(*43*)	Consecutive newborns (screened by sex chromatin and Y body fluorescence)	3097	3	4	0
Toronto 2	(*44*)	Consecutive newborns (screened by sex chromatin and Y body fluorescence)	1735	2	0	0
Toronto 3	(*44*)	Consecutive newborns (screened by Y body fluorescence)	3660	3	—	—
Munich	(*130*)	Newborns	486	0		

* The distribution by race in the United States is as follows. New Haven: 3 white XYY, 3 white XXY, 1 black XXY; population 77 percent white, 18 percent black, 5 percent other (*40*). Pittsburgh: 2 white XYY, 1 white XXY, 1 black XXY, 1 black XXYY, population approximately 15 percent black (*105*). Boston study 1: about 86 percent white, 2 percent Oriental, 12 percent black. Boston studies 2 and 3: about 84 percent white, 13 percent black, 3 percent other (*42*). All Boston studies: 3 white XYY, 8 white XXY, 4 black XXY, 1 Oriental XXY (*42*). Denver: 2 XYY white, 1 XYY Spanish-American, 2 XXY white, 2 XXY Spanish-American, population (estimate) 25 percent Spanish-American, 10 percent black, 65 percent white (*43*). The total frequencies in whites are: 10 XYY and 14 XXY in about 10,350; frequencies in blacks are: 0 XYY, 6 XXY, and 1 XXYY in about 1700. † X/ deleted XY. ‡ In addition there were two with apparently abnormal genotypes who could not be investigated extensively, one a probable XO male, and one a probable XYY/XY.

Table 2. Frequency of sex chromatin aneuploidy in male "normal" nonnewborn populations, not restricted by height.

Country	Reference	Population studied	No. studied	XYY	XY/XYY	XXY	XXYY	Other
Scotland	(*2*)	General adult population	482	0	0	1	0	0
Scotland	(*2*)	Hospital patients	929	0	0	0	0	XXY/XY
France	(*106*)	Subjects with phenotypes not differing from that of male normal population (732 with cancer)	1875	3	—	—	—	—
United States	(*37*)	Comprehensive child care clinic	539	0	0	0	0	0

Table 3. The frequency of males with sex chromosome aneuploidy in reports of mental-penal settings in which at least 20 patients were studied. There was no height restriction. (I) indicates incidence study.

Country	Reference	Population studied	No. in setting	No. studied	XYY		XY/XYY	XXY		XXYY	Other
					No.	%		No.	%		
Scotland	(3)	Wing for mentally subnormal in Carstairs maximum security hospital	203	197	7	3.6	0	0	0	1	XY/XXY
Scotland*	(4, 5)	Wing for mentally diseased, Carstairs	139*	*118**	*2**	*1.7**	*0**	*1**	*0.8**	*0**	*0**
Scotland*	(2, 5)	(I) Carstairs new male entrants	*	*111**	*1**	*0.9**	*0**	*2**	*1.8**	*0**	*0**
				229	3	1.3	0	3	1.3	0	0
England	(2)	Inmates of Darenth mental subnormality hospital detained under court order		182	3	1.6	0	4	2.2	0	0
United States	(37)	Mentally disturbed juvenile delinquents		59	2	3.4	0	0	0	0	0
Scotland	(2)	Security patients in Gogarburn mental subnormality hospital (see Table 5)		53	2	3.8	0	0	0	0	0
France	(9)	Psychiatric hospital "services de securite"		274	10	3.6	0	7	2.6	0	XXXY
Canada	(41)	Hospital for criminally insane		230	3	1.3	0	2	0.9	0	XYYY
Denmark	(107)	(I) Criminal psychopaths (Horsens)	108	97	2	2.1	0	2	2.1	0	XY/XXY
England	(71)	(I) Grendon prison, largely recidivist and psychiatrically disturbed population		204	2	1.0	0	2	1.0	0	XY/XXY
Greece	(23)	Mentally ill with criminal records		31	0	0	0	0	0	0	0
England	(48)	Mentally subnormal, security setting (Rampton)	680	615	22	3.6	0	14	2.3	4	0
England	(48)	Mentally subnormal, security setting (Moss Side)	291	255	10	3.9	0	4	1.6	3	XXY/XY
United States	(14, 25)	(I) Prisoners (mostly before trial) in whom psychiatric evaluation was felt to be indicated		973	3	0.3	0	4	0.4	0	0
Australia	(24)	Security wards of large psychiatric hospital	85	83	0	0	0	0	0	0	0
Denmark	(11)	(I) Forensic psychiatric clinic, Arhus (males referred by courts)	211	198	4	2.0	0	1	0.5	0	0
Denmark	(11)	Nykøbing State Hospital, forensic psychiatry ward		23	1	4.3	0	0	0	0	0
Denmark	(11)	Nykøbing State Hospital, security ward		35	0	0	0	0	0	0	0
United States	(15, 108)	Juvenile offenders, court psychiatric referrals		42	1	2.4	0	0	0	0	0
England	(109)	Coleshill Hall Hospital; retarded admitted on court order (see Table 5)		72	2	2.8	0	0	0	1	0
United States	(16)	Emotionally disturbed juvenile delinquents		103	0	0	0	2	1.9	0	0
Australia	(132)	Maximum security ward of a mental hospital		55	2	3.6	0	0	0	0	0

* For the purposes of some calculations in the text, these two separate sets of data have been considered as coming from a single study which is tabulated in the next lower horizontal line in the table. See (5) for explanation.

Table 4. The frequency of males with sex chromosome aneuploidy in reports of penal settings, in which at least 20 individuals were studied and no height restriction was stated. (I) indicates incidence study.

Country	Reference	Population studied	No. in setting	No. studied	XYY		XY/XYY	XXY		XXYY	Other
					No.	%		No.	%		
Scotland	(110)	16 approved schools (ages 8 to 18)	1125	1119	4	0.4	0	2	0.2	0	XY/XXY
Scotland	(110)	(I) Borstal entrants (ages 16 to 20)	617	607	1	0.2	0	2	0.3	0	XX
Scotland	(110)	(I) Prisoners, sentence 12 months, Saughton	325	302	0	0	0	0	0	0	0
United States	(17)	Nonpsychotic, nonretarded juvenile offenders (ages 8 to 16)	342	337	4	1.2	0	2	0.6	0	0
Greece	(23)	Young detainees (ages 13 to 25)		139	2	1.4	0	1	0.7	0	0
United States	(111)	Offenders with long sentences, state prison		190	0	0	0	0	0	0	0
United States	(37)	Adjudicated institutionalized juvenile delinquents (ages 8 to 18)		1112	2	0.2	0	0	0	0	XXY/XY
United States	(42)	Recidivist delinquent adolescents		25	1	4.0	0	0	0	0	0
Poland	(112)	Boys in approved school		30	0	0	0	0	0	0	0
Poland	(11)	Youth prison		151	3	2.0	0	2*	1.3*	*	*
Germany	(130)	Various prisons and detention centers		727	5	0.7	0	7	1.0	0	0
Italy	(133)	Reform school inmates		145	2	1.4	6	—	—	—	—
Mexico	(134)	Prisoners		236	0	0	1	1	0.4	0	†
England	(137)	Juvenile delinquents		385	2	0.5	0	0	0	0	3 X0/XYY
England	(137)	Juvenile delinquents		200	0	0	2	1	0	0	0
Thailand	(138)	Juvenile delinquents		100	0	0	0	0	0	0	0

* Klinefelter's syndrome, presumably XXY. † XY/XYY/XXYY.

Australia, and North America and include predominantly whites (*20, 21*).

The variation in the rates of occurrence of XYY's within mental-penal settings can probably be explained at least in part by fluctuation about a relatively small expectation and differences in admissions criteria between settings. Considering the seven negative reports, for instance, four were studies of relatively small numbers; the absence of any XYY's in these settings is not particularly significant (*22–24*). And the admissions criteria of the two largest negative reports to date (*14, 16*) were different from those of most of the other mental-penal settings with regard to documentation of a mental disorder (*7, 25*). The remaining negative study is that of a group of 58 retarded delinquents over 180.3 cm (71 inches) in Pennsylvania (*8, 26*). The admissions criteria here appear to have been very similar to those of settings in the United Kingdom (Table 3) in which very high rates were found (*9*). It is possible that the differences in racial composition of the groups as well as in the social factors contributing to placements in these settings may be relevant to the discrepancy (see below).

As might be expected, chromosome studies of exclusively penal or mental groups have not yielded such striking or consistent results as those of combined settings. Of 26 studies of exclusively penal groups in which positive results are not excluded, 9 have yielded rates greater than the appropriate background rate and 12 have yielded rates equal or below this. In 5 no decision is possible because of the sampling (Tables 4 and 7).

Not many exclusively mental settings have been studied, and no consistent trend has yet emerged (Tables 5 and 8). The variation in the observations from penal and mental groups probably also stems from the differences in admissions procedures. Reports of XYY individuals detected in exclusively mental settings indicate that such individuals often have a history of antisocial behavior (see *15*), whereas the descrip-

Table 5. The frequency of males with sex chromosome aneuploidy in reports of mental settings, in which at least 20 individuals were studied and no height restriction was stated.

Country	Reference	Population studied	No. in setting	No. studied	XYY		XY/XYY	XXY		XXYY	Other
					No.	%		No.	%		
Scotland	(*2*)	Prudhoe Hall Mental Subnormality Hospital*		597	0	0	0	2	0.3	0	†
Scotland	(*2*)	Gogarburn Mental Subnormality Hospital‡		370	0	0	0	0	0	1	0
Scotland	(*2*)	Epileptics		76	1	1.3	0	1	1.3	0	0
France	(*113*)	General psychiatric ward		399	2	0.5	0	3	0.8	0	0
England	(*109*)	Coleshill Hall Hospital§		161	1	0.6	1	0	0	0	0
United States	(*114*)	Consecutive referrals to children's psychiatric clinic	496	496	2	0.4	0	3	0.6	1	XXX/XY
United States	(*37*)	Institution for mentally disturbed boys		85	1	1.2	0	0	0	0	0
Poland	(*112*)	Patients with mental subnormality		59	0	0	0	1	1.7	0	0
Canada	(*135*)	Patients with mental retardation¶		283	1	0.4	0	0	0	0	XXYY

* Includes 61 mongoloids. † XXY/XXXY and XXXY/XXXXY. ‡ See Table 3 for maximum security patients. § Retarded, not admitted by court; compare with Table 3. ‖ About 25 percent for retardation. ¶ Includes 56 mongoloids.

Table 6. The frequency of males with sex chromosome aneuploidy in reports of mental-penal settings, in which at least 20 individuals were studied. The populations studied were restricted by height.

Country	Reference	Population studied and characteristics	No. in setting	Height restriction (cm)	No. fitting criteria	No. studied	XYY	XY/XYY	XXY	XXYY	Other
England	(*115*)	Sex-chromatin negative, mentally ill in maximum security setting (Broadmoor)	~ 650	≧ 182.9	?	50	4	0	—	—	—
United States	(*50, 51*)	Mentally disordered sex offenders (Atascadero)	~ 700	≧ 182.9	?	79	7	0	2	1	0
United States	(*50, 51*)	Mentally ill, criminally insane (Atascadero)	~ 700	≧ 182.9	?	121	2	1	0	0	2*
United States	(*10*)	Violent, destructive, hard to manage psychiatric patients	?	≧ 182.9	?	26	0	0	1	0	0
Denmark	(*116*)	Psychologically abnormal criminals (Herstedvester)	155	≧ 182.9	42	37	2	0	0	0	0
Denmark	(*107*)	Criminal psychopaths (Horsens)	217	†		135	1	0	3	0	§
France	(*117*)	Psychopathic delinquents (Sarreguemines)	?	> 178	?	27	5	?	?	?	?
United States	(*8*)	Mentally ill in city prison	?	> 180.3	?	22	1	0	0	0	0
United States	(*8, 9*)	Mentally retarded in state prison	?	> 180.3	?	58	0	0	3	0	0
United States	(*8*)	Criminally insane	?	> 180.3	?	80	3	0	4	0	0
United States	(*66*)	Four Midwest, maximum security hospitals, including mentally retarded and mentally ill	?	≧ 182.9	?	210	10	?	?	?	?
United States	(*35*)	Defective delinquents	464	≧ 188.0‡	22	21	2	0	0	0	0
Germany	(*118*)	Rottland sanitarium; mentally retarded or ill in security setting	700	≧ 178	?	35	7	0	?	?	?
Australia	(*131*)	Alcoholic prisoners	?	Some tall (?)	?	92	2	0	2	0	XXY/XY
Australia	(*131*)	Dull or psychopathic prisoners	?	Some tall	?	47	3	0	0	0	0

* XXpiY and XYY/XXYY. † Nielsen *et al.* (*107*) describe their sample "among the tallest and most immature." No exact height cutoff is given. ‡ The tallest 5 percent were studied (*35*), which corresponds roughly to those taller than 188 cm. § XY/XY?Xq—

tion of XYY's in general prisons or other exclusively penal settings indicates that at least some of them are mentally disordered (*27*). The rates here are thus likely to depend on how narrowly admissions criteria are applied, and the likelihood or availability (or both) of other perhaps more restrictive placements in the same jurisdiction.

If a distinction is not made between mental-penal and other settings in which deviant individuals may be placed, then the most striking observation is the great heterogeneity in rates. Such an approach has apparently led some to imply that the original Carstairs studies might reflect a type 1 error, that is, a "false positive" result (*28, 29*). But as already seen, there is no question that the prevalence rate of XYY's is markedly increased over baseline in those in mental-penal settings that have been subsequently studied.

Three additional points are pertinent concerning the evidence. First, most studies cited in Tables 3–8 provide prevalence rates (rates of individuals in particular settings at one particular time). Very few studies provide the "incidence" rate (*30*) of new individuals admitted to an institution over a particular time span. Those that are known to do so are indicated by the symbol (I) in Tables 3–8 (*31*). If XYY's were admitted to those settings at the same rates as XY individuals, but were kept longer before discharge (a phenomenon that would be of significance in itself), prevalence rates would be greater than those in the normal or

Table 7. The frequency of males with sex chromosome aneuploidy in reports of penal settings, in which at least 20 individuals were studied. The population was restricted by height. (I) indicates incidence study.

Country	Reference	Population studied and characteristics	No. in setting	Height restriction (cm)	No. fitting criteria	No. studied	XYY	XY/XYY	XXY	XXYY	Other
Scotland	(*110*)	Three institutes for young offenders	?	≧178	74	74	1	0	0	0	0
Scotland	(*110*)	Various prisons	?	≧178	453	419	1	0	2	0	0
England	(*115*)	Intermediate sentence, general prison, sex chromatin negative (Nottingham)	~250	>182.9	?	24	2	0	—	—	0
United States	(*119*)	Volunteers in general prison	2000	≧185.4	?	100	2	0	2	0	0
Australia	(*120*)	General prison (includes high grade defectives and psychotics)	1200	≧175.3	?	40	5	?	?	?	?
England	(*121*)	Approved school	1021	*	34	29	3	?	?	?	?
United States	(*15*)	Maximum security prison volunteers	2100	≧182.9		86	2	0	0	0	0
England	(*27*)	(I) Wandsworth prison (mostly recidivists)	?	≧182.9	?	34	2	?	?	?	?
England	(*27*)	Wandsworth prison	?	≧180.3	?	31	1	?	?	?	?
England	(*27*)	(I) Wandsworth prison	?	≧180.3	?	290	6	?	?	?	?
Ireland	(*122*)	General prison	?	≧177.5	?	67	0	?	?	?	?
United States	(*123*)	Federal prisoners, recurrent criminality, not psychotic, no brain damage, Army alpha 70 to 80	2200	≧182.9	27	22	0	0	0	0	?
Canada	(*124*)	Sentenced offenders; persistent antisocial and aggressive behavior	500	>182.9		51	2	0	0	0	?
United States	(*125*)	Negro prisoners	?	>182.9	?	100	0	0	0	0	0
United States	(*8*)	Detention center (ages 14 to 16)	?	>180.3	?	32	1	0	1	0	0
United States	(*8*)	State prisons	?	>180.3	?	73	2	0	1	0	0
Japan	(*126*)	Juvenile delinquents (ages 14 to 19)†	1504	≧174	?	100	0	?	?	?	?
Poland	(*112*)	Adult criminals	1490	>183	?	33	0	4	0	0	?
Mexico	(*136*)	Prisoners	941	≧173	94	78	0	0	2	0	0

* Taller than 90 percent of the general population, according to national published charts (*121*). † Mean, 167.7 ± 5.9 cm, but only those ≧174 cm were studied.

Table 8. The frequency of males with sex chromosome aneuploidy in reports of mental settings, in which at least 20 individuals were studied. The studies were restricted to tall men. (I) indicates incidence study.

Country	Reference	Population studied and characteristics	No. in setting	Height restriction	No. fitting criteria	No. studied	XYY	XY/XYY	XXY	XXYY	Other
England	(*115*)	Sex chromatin negative, mentally ill	?	>182.9		30	0	0	—	—	—
Norway	(*127*)	(I) St. Jorgen mental hospital		≧183	99	117	3	1	2	0	XY/XXY
Norway	(*127*)	Lillhagen mental hospital			18						
United States	(*15, 108*)	Gowanda mental hospital	?	≧182.9	76	76	1	0	0	0	0
England	(*128*)	Mental retardates, Darenth Park (see also Tables 3 to 5)	917	177.8 to 181.6	49	47	0	0	2	0	0
				≧182.9	19	19	2	0	1	1	1
United States	(*8*)	Hospitalized mentally ill	?	>180.3	?	164	0	0	2	0	0
United States	(*8*)	Retarded	?	>180.3	?	20	1	0	2	0	0
United States	(*66*)	Retarded	?	≧182.9	?	32	1	?	?	?	?
United States	(*129*)	Retarded over 14	~1350	≧175.3	~80	55	1	0	0	0	0
Sweden	(*12, 13*)	Alcoholics primarily with history of criminal record	184	≧180	50	42	0	0	0	0	0
Sweden	(*12, 13*)	Alcoholics primarily without history of a criminal record	275	≧180	52	47	0	0	0	0	0

background population but incidence figures would be the same as the baseline. But four of the five institutional "incidence" figures listed in Table 3 reveal rates above the background.

Second, the frequency of deviant XYY's detected may be slight underestimates because it appears that XYY individuals may be less likely than XY's in the same setting to provide blood specimens (*32, 33*).

Third, the prevalence rate of XYY's is higher in whites than blacks in studies of those diverse settings in the United States in which deviant individuals have been found (*34–37*); and in fact, there are as yet no extensive data documenting an association of the XYY genotype with deviant behavior in any nonwhite group. A differential concentration of tall whites in settings for deviant individuals seems unlikely to account for the racial differences. The difference may be due to one or more of three factors—(i) a true difference in newborn rate (Table 1) or differential survival of XYY's, (ii) a more benign behavioral prognosis of the XYY genotype in blacks, or (iii) relative differences in other factors contributing to deviance in our current social setting.

Nature of the Association

It is much more difficult to establish why XYY's are more likely to be found in mental-penal settings. Three types of general hypotheses may be distinguished. (i) The XYY genotype occurs more often in groups in which for independent reasons deviant behavior is more frequent—an associative etiology. (ii) Some physical (or external) correlate of the genotype, such as large height, results in a phenotype that makes social adaptation less likely and institutionalization more frequent—a social etiology. (iii) The XYY genotype results, directly or indirectly, in some aberration of neural development that tends to result in deviant behavior —a neural etiology. These are not necessarily mutually exclusive.

The Associative Hypothesis

The question arises as to whether XYY males are born more frequently than XY's into circumstances in which environmental factors are usually presumed to be responsible for a higher incidence of deviance. There are very few direct data on this point (*38–44*), but indirect evidence from studies of institutions suggest that this is improbable. The XYY's in settings for deviant individuals do not appear more likely to come from families of lower socioeconomic status or have more relatives with criminal histories than XY's placed there; the trend is in the opposite direction in at least some studies (*45–51*). While further data from studies of newborns would be desirable, it appears that this hypothesis cannot account for the entire association with institutionalization for deviance, and is unlikely to account for a significant fraction of the association (*52*). This of course does not mean that adverse environmental (or other genetic) factors cannot heighten a risk already elevated for other reasons.

The Social Hypothesis

Because a tendency to larger height in the XYY individual has been noted in almost all population studies (*53*), size alone has been considered as a possibly significant factor. Personality patterns developing in children as a reaction to large height or "channeling" by social forces of tall individuals (who may appear more threatening), conceivably could account for the observed frequencies of institutionalization (*54, 55*). It is easy to imagine why a tall deviant individual who has difficulty with impulse control may be more likely to be placed in custody than a short individual with similar behavior, and probably several XYY's may be in custody more because of their size than their behavior [for example, case 10 of (*56*)]. But if, for whatever reason, large size contributes significantly to the frequency of XYY in settings for deviant individuals, one should also expect an enrichment of tall XY's in such placements. Evidence for an increase would be provided if there were an increase in either the modal height of XY's compared to some published norm, or if there were some skewing or a shoulder in the distribution curve toward larger height.

There are two settings in which there does appear to be a concentration of tall (XY) individuals (*23, 57*), so that this factor may be operative at least within some jurisdictions (*58*). Nevertheless, data from other settings with a high prevalence rate of XYY's do not provide evidence for a significant concentration of tall males (*4, 48, 55, 57*).

One may ask whether there are other physical features of the XYY phenotype which might function in the manner postulated above for large height. Severe acne appears to be present more frequently in XYY's than in XY's. Voorhees *et al.*, for instance, found 4 XYY's in a group of 100 prisoners with nodulocystic acne, 2 XYY's in a group of 100 "normal" males with nodulocystic acne, but none in a group of 100 unaffected control prisoners (*59*). But the extent of moderate to severe acne among institutionalized XYY's with deviant behavior is probably under 50 percent and thus not high enough to account for the increased prevalence of XYY's in such settings (*60, 61*). Furthermore, the incidence of nodulocystic acne in prisoners, 5 percent, is not markedly greater than the rate in the general population although, admittedly, diagnostic criteria may not be consistent among different studies and data from mental-penal settings are not available (*62*). Dermatoglyphic differences between XYY and XY individuals have been well documented (*63*), but these seem not even remotely likely to be responsible for behavioral differences.

A large number of anecdotal reports of other signs in XYY individuals have appeared. But for none is there strong evidence that there is even a small enrichment in XYY's, with the possible exceptions of radioulnar synostosis (*64*)—which still must be quite rare in XYY individuals—and prolonged cardiac conduction (*64*). Case reports indicate that particular XYY individuals may display many of the abnormalities that some XY's do—not a surprising observation—but provide no data on the relative frequency in XYY's compared to XY's. Thus sporadic reports of morphologic abnormalities of the genitalia in XYY males, and occasional instances of male pseudohermaphrodites (that is, with female phenotype), may only reflect the greater likelihood that individuals with genital anomalies would have a chromosome study. And many of these cases are probably cryptic XO/XYY mosaics [for example, (*65*)].

In meticulous neurological examination of 12 XYY's detected in mental-penal or mental settings, Daly found slight (soft) neurological defects, mostly motor dysfunction (such as intention tremors) in at least 10 and slight body asymmetries in 6 individuals (*66*). Unfortunately no data are available on XY patients in these settings. Griffiths noted similar (nontraumatically in-

duced) neurological abnormalities in 3 of 9 XYY's and in 1 of 9 control XY prisoners (*27, 67*). It is certainly conceivable that such neurological abnormalities might, by social mechanisms similar to those postulated for large height, account for the greater prevalence rate in mental-penal settings in that individuals who have fewer motor skills and less coordination (even though themselves unaware of the defect) may be more likely to manifest deviant behavior.

Other studies, however, have not revealed such a high rate as that Daly found although it is always possible that the neurological examinations were not as meticulous. In nine institutionalized XYY's, in some of whose histories head beating, alcoholism, and frequent fights were prominent, no neurological abnormalities were observed (*8*). In series which I personally observed, of four XYY's with deviant behavior who received careful neurological examination, only one showed evidence of such "soft" signs as tremor and incoordination; and of 33 XYY's in mental-penal settings (*48*) who were neurologically reinvestigated after Daly's report, only one was stated to have a minor neurological abnormality detectable on physical reevaluation (bilateral nystagmus) (*68*).

There are no other phenotypic characteristics of which I am aware which can at present be invoked to explain the high rate of XYY's in mental-penal settings.

The Neural Hypothesis

Direct evidence for some type of brain dysfunction is elusive, however (*69*). Electroencephalograms (EEG's) of many XYY individuals in custody have been reported as "normal," although in such cases there usually has been no statement as to whether sleep or metrazole stimulation studies were performed, or whether sphenoid electrodes, which are more likely to detect temporal lobe abnormalities (although dangerous to employ), were used. Probably most unqualified reports have just been limited to EEG's with scalp electrodes, while the subject was awake, and thus it is likely that at least some otherwise detectable abnormalities may have been missed. In two studies in which tracings of nonepileptic institutionalized XYY's were compared to those of controls in the same settings, there was a trend to greater frequency of abnormalities in the XYY's (*70–72*). But no marked increase in the frequency of clinical epilepsy has occurred in XYY patients in custody. For instance, Casey *et al.* found a history of epilepsy in 15 percent of 33 XYY patients and in 18 percent of 154 randomly chosen XY individuals in the same settings (*48*).

Cryptic seizure disorders that are difficult to diagnose by conventional means and are associated with marked antisocial behavior have been described (*73*). There is, however, to date no documentation of these in deviant XYY individuals.

Endocrine abnormalities involving hormones known to have an effect on behavior would be at least consistent with some type of (secondary) brain dysfunction. But determinations of testosterone, as well as of pituitary gonadotrophins, growth hormone, 17-keto steroids, 17-hydroxy corticosteroids, and luteinizing hormone have not revealed consistent abnormalities (*29*). In most cases, when elevations have been noted, the normal values used for comparison have not been from XY individuals in the same settings. All XYY's studied to date, however, have been adults or adolescents. It remains possible that hormonal abnormalities have occurred, but earlier in development, perhaps even prepartum, affecting central nervous system differentiation as well as long-term growth patterns (*74, 75*). Alternatively, some differential end organ response between XYY's and XY's may be responsible.

Should the neural hypothesis be correct, the presumed responsible physiologic factors might be operative in only some fraction of XYY's or operative in all to some extent, but only associated with the deviance of those in whom there is already a predisposition to such behavior for other reasons. There is, of course, a gradient between those two possibilities which might be labeled as "threshold" and "continuum" alternatives, respectively (*76*). Neither implies necessarily that endogenous or exogenous factors could not modify the risk of antisocial behavior. Under either hypothesis, particular environmental factors might be necessary conditions for the subsequent manifestation of deviance in XYY's, as some have suggested (*15*). Thus a neural etiology does not preclude the possibility of effective preventive or therapeutic measures.

But aside from the trend in the electroencephalographic data the only evidence to date for the neural hypothesis is that there is no evidence against it and that at present the other hypotheses do not plausibly explain the entire association with deviance.

The treatment of the three types of casual hypotheses separately does not exclude the possibility that they are interrelated. For instance, endocrinologic abnormalities that directly influence behavior through an effect on the central nervous system may also have indirect effects if they result in physical phenotypes that affect social adjustment. The minor neurological abnormalities that may have social consequences in themselves can also be regarded as independent signs of some central nervous system disorder. A strict sorting out of neural and social factors may prove difficult.

Other Behavioral and Psychological Findings

Documentation of consistent behavioral and psychological differences between deviant XY and XYY individuals provides no direct evidence concerning the three types of etiologies already discussed. The available data on these questions are still of interest, however.

A wide spectrum of IQ's has been noted in XYY individuals. In at least three settings that were not specifically for retarded individuals, the IQ's of XYY's in custody were lower than those of institutionalized controls (*17, 77, 78*). Griffiths, for instance, found the average IQ of 12 XYY prisoners to be 95 compared to a mean of 108 in 12 controls matched by age and height, a statistically significant trend which was noted on both performance and verbal scales (*77*). Reports of IQ's from security settings specifically for the retarded have not revealed consistent differences, however (*45–49*). These data, in conjunction with the prevalence rates summarized in the tables, suggest that (i) the behavioral manifestations of the phenotype in XYY's in custody tend to interfere with acquisition of a (measurably) normal intelligence, or that (ii) the same events that resulted in deviant behavior also influenced intelligence.

Griffiths *et al.* also found lower sociability and extroversion in his series of XYY prisoners compared to XY controls (*27, 77*); Hope *et al.* noted differences in psychological defensive-

ness between institutionalized XYY's and XY's and suggested that the two groups might have differed in "conceptions of what is acceptable" (*79*). These observations may be related to differences in intelligence of those tested because others have found no notable psychological differences between deviant XY's and XYY's where there was no marked discrepancy in IQ levels (*49, 78–80*).

Publicity given to the first published reports of settings for deviant individuals gave rise to the unfortunate popular stereotype of XYY individuals as the most physically aggressive and violent individuals (an impression reinforced in the United States by false newspaper reports that Speck, the Chicago mass murderer emblazoned with the tatoo "born to raise hell," was an XYY). But in those mental-penal and penal settings where XYY's have been found, they do not appear to be concentrated among the most dangerous, violent, and physically aggressive inmates. And, in general, their offences are similar to or less serious than those of XY's there (*81*). Increased impulsiveness, rather than greater aggressiveness per se, appears more likely to be the relevant factor, but there are no objective psychological data yet available on this point (*82*).

Magnitude of the Risk

The risk of an XYY newborn eventually manifesting significant deviant behavior probably depends upon the circumstances into which he is born. At least the absolute risk must be measured against a specific background. But in the total (white) population, on the assumption that the incidence of XYY's is about 0.11 percent and that the prevalence of XYY's in mental-penal settings is 2 percent, then, while there may be an 18 times greater likelihood of an XYY being found in such custody, only a relatively small fraction of the total number may be there at any time. For instance, if as many as 1 in 500 adult white males in the population are in mental-penal settings then, from the above rates, in every cohort of 1 million males there will be about 1100 XYY's, about 3½ percent of whom (40 of 1100) will be in such custody at some time as adults (on the assumption of constant incidence and no differential mortality). This risk, about 1 in 28, is relatively small but decidedly increased compared to the background rate. *This figure is a rough estimate for illustrative purposes only. It is only applicable if the numerical assumptions are correct now and in the future* (*83*). *It should not be cited as a definitive risk figure.* Furthermore, this is only the risk of an individual being found in a mental-penal setting at any given time as an adult. It is not relevant to the risk of an XYY newborn eventually manifesting deviant behavior, which is likely to be higher.

There is scant information derived from observations of behavior in XYY's discovered in systematic studies unrelated to deviancy. Antisocial behavior has not been prominent in XYY's with hypogonadism or male pseudohermaphroditism. This is not relevant to the risk in sexually normal XYY's who constitute the vast bulk of reported cases, since many of the former are overt if not cryptic X0/XYY mosaics, and the X0 line or other endocrine related factors associated with abnormalities of male differentiation may have had ameliorating effects upon behavior.

About all one can conclude from the very few other series of XYY's not biased by behavioral ascertainment is that deviancy has not been a prominent finding. For instance, neither of two XYY's detected in a series of outpatients with nodulocystic acne manifested overt evidence of antisocial behavior (*59*), and of six XYY males detected in practice by experienced neurologists looking for the syndrome (*66, 84, 85*) only two manifested antisocial behavior, and the decision to study these cytogenetically may have been biased by that knowledge (*85*).

The question of the extent of the risk will not be satisfactorily answered until a large, prospectively ascertained group is studied with suitable "blind" precautions. As of November 1970, at least 17 XYY males diagnosed at birth in the United States, Canada, and Scotland were being sequentially evaluated (*86*). Recent discovery of distinctive interphase fluorescent patterns of cells with two Y chromosomes has enabled more rapid screening of newborn and older populations and detection of much larger numbers of XYY individuals. In addition, a collaborative cytogenetic study of about 11,000 7- and 8-year-old males who were ascertained at birth in the perinatal study of the National Institute of Neurological Diseases is in progress (*40*). Many psychological data are already on hand concerning this entire population. But if the prevalence of deviant behavior in XYY's is relatively small, even larger populations may have to be investigated to document statistically the magnitude of the risk.

XXY Genotype

Interest in the behavioral implications of the XYY genotype has also drawn attention to the possible association of other sex chromosomal disorders of males with deviance.

The XXY genotype is almost always associated with infertility and hypogonadism and produces the phenotype known as Klinefelter's syndrome. Height tends to be increased, but not to the extent in the XYY genotype. A good deal of data concerning "background" rates of the XXY genotype is available, since many sex chromatin surveys (which reveal males with extra X chromosomes) have been done. These, as well as the chromosome studies summarized in Table 1, indicate that the probable newborn rate in whites in North America and Europe is unlikely to be greater than 1 in 250 (0.4 percent) and probably is about 1 in 900 (0.11 percent) (*87–89*).

For comparison with prevalence figures of institutionalized males, a presumptive maximum background rate of 0.4 percent (1 of 250) XXY's will be used. Of the 26 studies of mental-penal settings summarized in Tables 3 and 6, in which a positive conclusion could be reached, 11 were positive, 14 were negative, and 1 was indeterminate or borderline. Twelve of the negative studies were from rather small groups. One percent would appear a reasonable estimate of the frequency of XXY's in studies of the type summarized in Table 3. In exclusively penal settings there are 4 positive, 15 negative, and 2 indeterminate studies of those where a positive conclusion could be reached. For the exclusively mental settings summarized in Tables 5 and 8 there is no consistent increase, but data from other surveys are pertinent. Summarizing five North American studies, Court Brown noted 1 to 2 XXY's in 901 males whose IQ's were under 20, and 13 to 14 XXY's in a group of 2631 retarded males whose IQ's were over 20 (*88, 90*). It thus appears that XXY's are likely to be increased in settings for

high-grade retardates, but the prevalence rate is only five times the probable background rate of 0.11 percent or just slightly greater than the presumptive maximum.

Taken together, the data suggest that the XXY does have an increased risk of appearing in a mental-penal setting, but not as great a risk as an XYY. He is more likely than the XY [and possibly the XYY (*49*)] to be a high-grade retardate.

The same racial trend noted for the XYY genotype is present here as well (*91*). A lower newborn rate in blacks is unlikely to account for this difference at least, on the basis of incidence studies reported to date (Table 1).

The nature of the association with deviancy could be explained by hypotheses discussed above in connection with the XYY genotype. There is no strong evidence for the associative or social hypothesis (*92*) and no direct evidence for a neural etiology apart from electroencephalographic data similar to that discussed above (*70–72*).

XXYY Genotype

XXYY individuals also have the phenotype of Klinefelter's syndrome although they are taller than the average XXY and often have bony abnormalities. The incidence of XXYY's in the total of the newborn populations studied to date is about 1 in 25,000 (0.004 percent) (Table 1 and *87*).

In the patients in mental-penal settings summarized in Table 3, there were nine XXYY's (eight in security settings for retardates), a rate of 0.2 percent. This appears to be about a 50-fold increase over the newborn rate, but the confidence limits are wide. There were three in the exclusively mental settings for retardates, and one among tall inmates of mental-penal institutions. Among 3532 high-grade mental retardates in other studies, there were three cases (*88*). Thus not only is there evidence for an increase in both retardation and deviant behavior in these individuals, but the magnitude of the increase compared to the background rate appears to be far greater than that observed in the XXY individual (*48*), thus providing additional evidence for the behavioral significance of an extra Y chromosome. Whatever factors are responsible for deviance in XXY and XYY individuals are likely to be operative here as well.

Some Further Questions

The data I have reviewed so far indicate that only to the first of the questions posed in the introduction can an answer be given with confidence. There is a definite association between the XYY genotype and presence in mental-penal settings, but both the nature and extent of this association are yet to be determined.

Discovery of an extra sex chromosome in a male hardly predicts antisocial behavior with the confidence, for instance, that the observation of trisomy 21 (the chromosome pattern associated with mongolism) predicts mental retardation. This raises a serious dilemma for the physician as to whether and how to advise the parents when a sex chromosome abnormality is detected in a male infant or child in whom the diagnosis has not been suspected clinically.

Telling the parents of the diagnosis and possible prognosis is likely to induce more difficulties for both child and family than not informing them, particularly since the precise behavioral risks are uncertain and there are no therapeutic or preventive measures known at present that are specific for an individual with XYY (or XXY) genotype.

But the latter course opens the physician to a charge of withholding information even when he has acted in what may be the best interests of all concerned (*93, 94*). Furthermore, if deviant behavior patterns in a child with abnormal genotype have emerged, it may be considerably reassuring for the parents to know that there is a specific genetic hypothesis to account for these and perhaps to relieve them of guilt feelings concerning their child-rearing role.

It is even more difficult to make a generalization as to whether and when an affected individual himself should be told of the diagnosis. Under some circumstances at least, he might wish to know his genotype. For instance, an XYY individual without antisocial behavior might be concerned about having an XYY son, although this risk at present seems small (*95, 96*). An XYY individual in a penal or mental-penal setting conceivably might wish to introduce the fact into his legal defense, although the likelihood of its being useful to him in this context appears remote at present (*97*).

An even greater dilemma arises when an XYY genotype is detected "incidentally" in cytogenetic study of amniotic fluid cells from a woman who has sought the study because of concern about some other genetic disorder of the fetus, such as mongolism (*98*). Here of course the information cannot be withheld, and an attempt must be made to enable her to reach an informed decision about terminating the pregnancy, a procedure which, presumably, she is already considering since she has already sought the diagnostic procedure. Clearly a precise risk cannot be cited, particularly since the possible influences of environmental and other genetic factors upon a particular individual cannot be anticipated. One course would be to advise that she may have an apparently normal child but that it appears likely that he will be at greater risk, as compared to an average XY boy she might have, of eventually manifesting deviant antisocial behavior. Whether this view does justice to the available data, each reader must judge for himself. It would at least be hazardous to assure the parent that the risks are trivial. Furthermore, it cannot be presumed from the discussion above that the risks necessarily apply only to whites since, as already noted, purely social factors may account for the racial differences in observed rates in settings for deviant individuals.

Thus there is a clinical need to document the behavioral natural history of these genotypes. But such knowledge is important for other reasons as well. The significance of the association with deviance may be out of all proportion to the strength of the association and the numbers affected. Males with sex chromosome abnormalities constitute a well-defined group in which the pathophysiology of some types of antisocial behavior can be studied. Investigation of hypotheses generated by study of these genotypes may lead to further knowledge concerning both biologic and social factors leading to institutionalization of the vastly greater numbers of XY individuals in various jurisdictions.

For instance, it is possible that the rates of sex chromosome abnormalities in a setting may provide some indirect evidence concerning the relative importance of socioeconomic factors in contributing to the placement there of men with normal XY genotypes. Given two groups within a single mental-penal setting, or two different settings with identical admissions criteria, a lower

rate of XYY's might be expected in that group (or setting) for whom adverse social and economic factors have contributed more strongly to admission of men with normal XY karyotypes. [This would presume that (i) adjustments have been made for such factors as differential concentration of tall men in these groups or settings, (ii) admissions criteria stated to be identical are, in fact, interpreted similarly for both groups or settings, and (iii) incidence rates of male sex chromosome abnormalities, as well as genetic factors associated with deviance in XY's (*99*), are roughly equal in the two populations from which the men in these settings are drawn. Conversely, in jurisdictions where social factors have resulted in very low rates of deviance, it would not be surprising if biologic factors such as sex chromosome abnormalities were found to be proportionately more heavily represented in the (perhaps relatively few) men who were in custody in mental-penal settings. If these suggestions are correct, then in one sense the rates of sex chromosome abnormalities in mental-penal settings within particular populations may prove to be inverse markers of the relative importance of adverse social and economic factors in contributing to placement in these settings. This would not imply that detrimental environmental factors did not contribute significantly to admission to mental-penal settings where the rates were high, but only that the contribution was of lesser magnitude than for entrance to settings where admissions criteria were similar but the rates were low. I emphasize that these considerations are hypotheses and only that, which must be refined and tested in the course of future investigations through the next decades.

References and Notes

1. S. G. Ratcliffe, A. L. Stewart, M. M. Melville, P. A. Jacobs, A. Keay, *Lancet* **1970-I**, 121 (1970).
2. P. G. Smith and P. A. Jacobs, in *Human Population Cytogenetics*, P. A. Jacobs, W. H. Price, P. Law, Eds. (Edinburgh Univ. Press, Edinburgh, 1970), p. 159.
3. P. A. Jacobs, M. Brunton, M. M. Melville, R. P. Brittain, W. F. McClemont, *Nature* **208**, 1351 (1965). The mosaic was later reported to have a third line as well.
4. P. A. Jacobs, W. H. Price, W. M. Court-Brown, R. P. Brittain, P. B. Whatmore, *Ann. Hum. Genet.* **31**, 339 (1968). The data from this study in Table 3 are those not included in the study of (*1*). See (*5*) for explanation.
5. Jacobs *et al.* have been publishing data from Carstairs sequentially (*2–4*). However, since the first study (*3*) can be regarded as the "index case" which led to the others at this institution, these are treated separately in Table 3. Probably the best approach in tabulating the number of positive settings would be to disregard the initial published report (*3*) and consider the subsequent data as from one, rather than two, additional studies. This approach has been taken with the tabulations although the data are separated in Table 3 because of the possible significance of differential admissions criteria.
6. The available rates for newborns are of course from contemporary studies, whereas the institutionalized males were born some years earlier. The data from Scotland suggest that there the rate in "normal" adults is at least not greater than the current rate for newborns: thus it is unlikely that current rates in institutions can be attributed to a markedly higher background rate in newborns some years ago.
7. The 35 studies of Tables 3 and 6 include all those mental-penal settings (as already defined) of which I was aware as of 1 September 1972, and in which at least 20 individuals were studied (a figure arbitrarily chosen before the analyses of rates were undertaken). It excludes data in groups of short males, such as those of Baker *et al.* (*8*), since negative results here are not significant. The decision as to which group to include and which to exclude, as well as how to classify studies of heterogeneous groups, must remain somewhat arbitrary. In general, I have tried to break down reports from a single setting into smaller homogeneous groups by diagnostic or admissions criteria where the information provided made this possible. Such an approach may inflate both the number of negative studies [perhaps (*10*)] and positive ones (see data on Coleshill Hall and Gogarburn in Tables 3 and 5). Some studies provided some difficulty in classification, and the rationale for their treatment here may not be obvious from the cited references. These were as follows: (i) Of the 198 patients from Arhus (*11*), somewhere between 29 and 42 were studied in one particular day (prevalence) and between 169 and 156 over the next 2½ years (incidence). No XYY's were detected in the small prevalence study, but I have not subdivided the total study because the admissions criteria, except for the temporal difference, were apparently constant. (ii) I have included in Table 3 two small studies from Nykøbing State Hospital (*11*), one positive and one negative under the assumptions (not stated in the reference) that this placement is for mentally disordered individuals, and that the sample was not height-truncated; these assumptions appear reasonable from the context of the data. (iii) No XYY's were found among 42 inmates over 180 cm in height from institutions for "alcoholics primarily with a criminal record" (*12, 13*). That there were also institutions for alcoholics primarily without a criminal record in this study and the boundaries between the two not very firm (*13*), suggests that the penal aspect of these settings, if any, is quite different from that of the other mental-penal settings considered in Tables 3 and 6. These data are therefore summarized in Table 8. (iv) In two settings classified as mental-penal [one negative (*14*), one positive (*15*)], delinquents were referred for psychiatric evaluation, presumably because of aberrant behavior, but were not specifically stated to have a mental disorder. Thus these two might be classified strictly as only penal. One other study, of Arhus (*11*), may also fall in this category. (v) The admissions requirement for one negative mental-penal setting (*16*) was stated to be for boys with "severe emotional disturbances and antisocial behavior." The evidence for emotional disturbance, however, was not a psychiatric evaluation but rather recurrent delinquency [P. Ferrier and D. E. Swenson, personal communication]. Thus this setting is similar to several classified as exclusively penal—for example (*17*)—and might appropriately be included in Table 4 rather than Table 3. (vi) See (*131*) below. (vii) In addition, between 1 September and 10 November 1972 I became aware of one report citing an additional small, negative (0 to 38) mental-penal study, and two indeterminate apparent mental-penal studies [G. R. Sutherland, S. Wiener, A. A. Bartholomew, M. G. Fitzgerald, *Med. J. Austral.* **1**, 1249 (1972)].
8. D. Baker, M. A. Telfer, C. E. Richardson, G. R. Clark, *J. Amer. Med. Ass.* **214**, 869 (1970). There were 58 tall, mentally retarded in the state prison studied (Table 6) (*9*).
9. D. Baker, personal communication.
10. S. Abdullah, L. F. Jarvik, T. Kato, W. C. Johnston, J. Lanskron, *Arch. Gen. Psychiat.* **21**, 501 (1969).
11. J. Nielsen, *Brit. J. Psychiat.* **119**, 503 (1971).
12. J. Wahlstrom, H. Forssman, H. O. Akesson, *Humangenetik* **9**, 105 (1970).
13. J. Wahlstrom, personal communication.
14. H. Witkin, personal communication.
15. M. J. Marinello, R. A. Berkson, J. A. Edwards, R. M. Bannerman, *J. Amer. Med. Ass.* **208**, 321 (1969); see also (*108*).
16. P. E. Ferrier, S. A. Ferrier, J. A. Nielson, *Ann. Genet.* **12**, 347 (1969).
17. E. B. Hook and D. S. Kim, *N. Engl. J. Med.* **283**, 410 (1970).
18. If indeterminate studies are excluded, and a one-tailed simple nonparametric "sign" test is used on the remainder, then for 21 or more positive and 5 or fewer negative studies, P is .001. For 21 or more positive and 7 or fewer negative studies, P is .006. If all the studies about which I have raised a question concerning evidence for a mental disorder [that is (*11, 14–16*)] are excluded from Table 3, then in the remaining 14, there are 12 positive and 2 negative studies. P is .006. ["Tables of the binomial probability distribution," *National Bureau of Standards, Applied Mathematics Series No. 6* (1949)].
19. It is difficult to estimate the bias of omission of those (completed) studies of which I was unaware when this review was completed. Probably most of these are unpublished small series. Limiting attention to those 9 of the 21 reports [excluding (3)] in which 180 or more individuals were studied should thus diminish this source of bias (a number chosen because the upper 95 percent confidence limit of zero in 180 is 2.0 percent). Eight of these nine are positive. The one negative study is borderline if only whites are considered (*14, 34*). (The others include only whites.) The pooled frequency, median, and mean in these nine are 1.90 percent (60 in 3160 and 59 in 2626, or 2.5 percent in whites only), 1.60 percent, and 2.07 percent, respectively. Four of the reports exclude a rate of 0.4 percent or less, with 95 percent confidence; one excludes a rate of 0.9 percent or more. All 95 percent confidence limits cited are from K. Diem, Ed., *Documenta Geigy Scientific Tables* (Geigy, Ardsley, New York, 1962). The sole exception to this trend in the large studies occurred in a study (*14*) in which there is some question concerning evidence for a mental disorder (*7*).
20. There are two negative studies of Orientals in exclusively penal settings (see Tables 4 and 7), and at least one case report of a deviant XYY man in Japan (*21*).
21. N. Hashi, *et al., Jap. J. Hum. Genet.* **14**, 34 (1969).
22. The observation of no XYY's in 31 men (*23*) excludes a rate of 11 percent XYY's or more in this setting; of no XYY's in 35 men (*11*), a rate of 10 percent or more; of no XYY's in 83 men (*24*), a rate of 4.4 percent or more; of no XYY's in 103 boys (*16*), a rate of 3.5 percent or more: all with 95 percent confidence [see also (*7*) on the admissions criteria of the latter group]. The absence of any XYY's in 26 tall, hard-to-manage psychiatric patients (*10*) excludes a rate of 13 percent or more in such a group; but this is not directly comparable to the other four studies, since an enrichment of XYY's would be expected among men of larger height. [In the same report (*10*), an XYY male was found among 18 tall, criminally insane men, a result excluded from the tabulation because fewer than 20 were investigated.]
23. N. Matsaniotis, C. Tsenghi, C. Metaxotou-Stavridaki, C. Economou-Mavrou, P. Bilalis, *Helv. Paediat. Acta* **25**, 253 (1970).
24. J. Mariks, R. M. Dunne, S. Walsh, *Med. J. Austral.* **1**, 827 (1971).
25. The prisoners were those that had been sent for psychiatric evaluation to one county hospital, usually before trial and not for long-term placement. In some cases, such as crimes of murder, the referral was mandatory, but usually it was discretionary and based on the view of a judge, a prison official, or the police (*14*). It is likely that individuals in this setting were less seriously disordered than, for instance, inmates committed to mental-penal institutions after psychiatric evaluation and trial.

26. The finding of no XYY's among the 58 individuals taller than 180.3 cm excludes a rate of 6.2 percent or more in this tall group, with 95 percent confidence. If this represents the tallest fifth of the institution, then, from the observations of security placements for the retarded in the United Kingdom, at least 10 percent might be expected to be XYY. There were also 22 under this height in this setting who were studied. [The absence of any XYY's in the 80 (total) excludes a rate of 4.5 percent or more XYY's.] Of the 79 on whom data are available, 39 were white, and 33 of these were more than 180.3 cm (*9*). The upper 95 percent confidence limit of zero in 33 observations is 10.6 percent.
27. A. W. Griffiths, B. W. Richards, J. Zaremba, T. Abramowics, A. Stewart, *Nature* **227**, 290 (1970); A. W. Griffiths, personal communication.
28. W. Hayes, in *Social Impact of Modern Biology*, W. Fuller, Ed. (Routledge & Kegan Paul, London, 1971), p. 92.
29. D. R. Owen, *Psychol. Bull.*, in press.
30. Strictly speaking, the incidence rate means the rate of onset of the condition over a specific period. The term is used here in quotation marks to indicate the rate of admissions of new XYY cases to a particular setting in a particular period.
31. Some of these include a small "prevalence" component as well. See, for example, comments on the Arhus study discussed in (*7*).
32. In the first Carstairs study of 203 men, 16 males refused a first request to provide blood, but 9 subsequently agreed. Two XYY's were found in these 9 compared to 5 in the first 187 ($P < .05$) (*33*). In the remaining 7 (those who refused), there was at least 1 male known from earlier studies to be XXYY.
33. W. M. Court-Brown and P. G. Smith, *Brit. Med. Bull.* **25**, 74 (1969).
34. E. B. Hook, in preparation. The XYY frequencies in 11 studies for which exact data are available are 28 of 2448 in whites, as compared to 7 of 1911 in blacks. In eight studies the rates in whites were greater, in one the same, and in two lower. Some of these studies were height-truncated, but the trend remains if such restricted studies are excluded. For mental-penal settings in Tables 3 and 6, for which exact racial data are available, the results are as follows: (i) Witkin (*14*): 439 white total, 2 XYY, 3 XXY; 400 black total, 1 XYY, 0 XXY; 132 Puerto Rican total, 0 XYY, 1 XXY; 2 others, both XY. (ii) Marinello *et al.* (*15*): 29 white total, 2 XYY, 0 XXY; 11 black total (and 2 Indian), 0 XYY, 0 XXY. (iii) Abdullah *et al.* (*10*): 15 white total, 0 XYY, 0 XXY; 11 black total, 0 XYY, 1 XXY. (iv) Welch *et al.* (*35, 36*): 11 white total, 2 XYY, 0 XXY; 32 black total, 0 XYY, 0 XXY. (v) Borgaonkar (Table 3) (*37*): 48 white total, 2 XYY, 0 XXY; 11 black total, 0 XYY, 0 XXY.
35. J. P. Welch, D. S. Borgaonkar, H. M. Herr, *Nature* **214**, 500 (1967). Subsequently the individual in this study with an apparent extra D chromosome was determined to be XYY with a marker chromosome 47 XYYt (6q-21qt) as well, and another XYY individual found, in the lower 95 percent for height (*36*).
36. J. P. Welch, personal communication.
37. D. S. Borgaonkar, *Excerpta Med. Int. Congr. Ser.*, No. 233 (1970), p. 31; personal communication.
38. Of the three newborn XYY's from New Haven (*39*), all were born to parents who were definitely not in the lowest 20 percent educational bracket (*40*). Among five detected in London, Ontario, three were born to middle class or lower-middle class parents, and two were born to families from lower socioeconomic groupings (*41*). Of three newborn XYY's studied in Boston one was a child of a felonious father of low socioeconomic background; the other two were from lower-middle and middle class backgrounds (*42*). Of the three in Denver, two were from lower-middle class and one of middle class background (*43*). Of the four in the second and third studies in Toronto for which data are available, all were born to lower-middle class backgrounds (*44*). The evaluations of socioeconomic status noted here are those of the authors cited, but are not necessarily based on the same criteria even when data on family income, life-style, and the like have been available, and must be regarded as subjective, and not necessarily indicative of the potential for delinquency that is present for social reasons. But the results indicate at least that XYY males are not exclusively born to families in the lowest socioeconomic groups.
39. H. A. Lubs and F. H. Ruddle, in *Human Population Cytogenetics*, P. A. Jacobs, W. H. Price, P. Law, Eds. (Edinburgh Univ. Press, Edinburgh, 1970), p. 119.
40. H. Lubs, personal communication.
41. F. Sergovich, personal communication.
42. S. Walzer, personal communication.
43. A. Greensher, D. C. Peakman, A. Robinson, personal communication.
44. A. Bell, personal communication.
45. The exact data are pertinent here since there is some heterogeneity among studies. In a study at Carstairs (*46, 47*) 9 XYY's were compared with 18 randomly selected controls, who were, on the average, both smaller and brighter than the XYY's. In seven of the families of the controls there was a history of criminal records in siblings, but in one family of an XYY there was such a history. Such a trend was not obvious in a study of 33 XYY's (11 from Moss Side and 22 from Rampton) by Casey *et al.* (*48*). The two institutions have similar admissions criteria (see Table 3) except that Rampton gets more dangerous patients. The controls were randomly selected. It appears from the descriptions of the populations here that the controls were, on the average, shorter. The mean IQ of the XY's at Rampton was 10 points lower than that of the XYY's [see also (*49*)]; at Moss Side the IQ's of the XY and XYY groups were about the same. At Moss Side, the frequency of XYY's with convicted first-degree relatives (1 in 11) was lower than that of XY controls from the same institution (20 in 104), whereas at Rampton it was slightly higher (8 in 22 as compared to 16 in 50); the entire increase at Rampton was apparently due to an increase of convicted brothers (14 in 41 as compared to 10 in 78). The rate of illegitimacy and parental desertion before age 6 was slightly higher in the history of XYY's than in XY controls (11 in 33 as compared to 37 in 154). Perhaps the most notable difference was a higher social class background of XYY's (institution unspecified) compared to XY's for whom data were available. The fathers of 18 of 26 XYY's were from class 1, 2, or 3, (the upper and middle social classes) but only 53 of 113 fathers of XY's in custody were of such status. Griffiths *et al.* found that a family background of alcoholic disorders was more frequent in XYY prisoners than in control XY prisoners who were matched by height but had higher mean IQ. But the reverse trend obtained with a family history of psychiatric disorder and criminal offense, although the differences were not marked. At Atascadero (*50, 51*) none of the nine XYY's came from families with a history of criminal activity. The expected frequency of such a history is about 12 percent, as judged by rates in the entire institution.
46. W. H. Price and P. B. Whatmore, *Brit. Med. J.* **1**, 533 (1967). This study was of inmates of Carstairs, according to Court-Brown (*47*).
47. W. M. Court-Brown, *J. Med. Genet.* **5**, 341 (1968).
48. M. D. Casey, C. E. Blank, T. Mobley, P. Kohn, D. R. K. Street, J. M. McDougall, J. Gooder, J. Platts, *Special Hospital Research Report No. 2, 1971* (Special Hospitals Research Unit, Broadmoor Hospital, Berks, England, 1971), pp. 1–48. In Table 1 of this reference 10 XYY's are indicated as having been detected in a prevalence study at Moss Side, while historical details are provided for 11 in subsequent discussion. The lower number is cited in my Table 3.
49. D. S. McKerracher, *Can. Psychol.* **12**, 270 (1971).
50. J. Melnyk, A. Derencseny, F. Vanasek, A. J. Ricci, H. Thompson, *Nature* **224**, 369 (1969).
51. F. Vanasek, personal communication.
52. There is also no available evidence whether XYY's are born more often to parents whose children are at greater risk to deviance for genetic reasons, regardless of an extra Y chromosome.
53. In the largest published report to date, from Rampton, one-half of the 22 XYY's were in the tallest 5 percent, and just over two-thirds were in the tallest 18 percent as estimated from the height graph (*48*). But XYY's of normal or short stature with deviant behavior have also been reported (*47*).
54. H. Hunter, *Lancet* **1966-I**, 984 (1966).
55. E. B. Hook and D. S. Kim, *Science* **172**, 284 (1971).
56. R. F. Daly, *J. Nerv. Ment. Dis.* **149**, 318 (1969).
57. J. P. Welch, R. A. Purdy, D. S. Borgaonkar, *Excerpta Med. Int. Congr. Ser.*, No. 233 (1971), p. 205. In both of the settings described here there was evidence for an enrichment of XYY individuals (*36*).
58. In one mental-penal setting, although the prevalence of tall XY males was increased, the prevalence of XYY's was not elevated [Table 3 and (*14*)]. This study is thus not directly relevant to the question of the increase of XYY's in other settings. [Despite the lower frequency of XYY's among blacks in this setting, the height enrichment of XY blacks here was greater than that of XY whites (*14*)].
59. J. J. Voorhees, J. W. Wilkins, E. Hayes, E. R. Harrell, *Arch. Dermatol.*, in press.
60. Acne in an XYY with deviant behavior was first noted by Telfer *et al.* (*61*). Since then, in two small series in which moderate to severe acne was specifically looked for, it was reported in three of nine XYY individuals (*59*). In five additional XYY's with deviant behavior, whom I observed, two had moderate acne.
61. M. Telfer, D. Baker, L. Lougtin, *Lancet* **1968-I**, 95 (1968).
62. J. W. Wilkins and J. J. Voorhees, *Arch. Dermatol.* **102**, 631 (1970).
63. D. S. Borgaonkar and E. Mules, *J. Med. Genet.* **7**, 345 (1970).
64. W. W. Cleveland, D. Arias, G. F. Smith, *J. Pediat.* **74**, 103 (1969) (on radioulnar synostosis) and A. M. Vianna, O. Frota-Pessoa, M. F. Dion, L. Decourt, *J. Med. Genet.* **9**, 65 (1972) (on prolonged cardiac conduction).
65. H. H. Punnett, M. L. Kistenmacher, A. M. DiGeorge, *Amer. J. Hum. Genet.* **22**, 23a (1970). Had this study been limited to blood lymphocytes, mosaicism would not have been detected.
66. R. F. Daly, *Nature* **221**, 472 (1969).
67. In addition, one XYY case had a posttraumatic, coarse tremor, and three of the XYY's, but none of the XY's, had nystagmus [A. W. Griffiths, personal communication]. Daly does not mention nystagmus in any of his 12 XYY cases.
68. An early report [D. R. K. Street and R. A. Watson, in *Criminological Implications of Chromosome Abnormalities*, D. J. West, Ed. (Institute of Criminology, Cambridge University, 1969), p. 65] limited to evaluation of 13 XYY's at Rampton and in which minor neurological abnormalities were found in five individuals (including two with intention tremors) appears to have been superseded by the cited later summary of all 33 XYY's at both Rampton and Moss Side (*48*). (But see also p. 42 of the latter.)
69. The neural hypothesis appears to have been first explicitly suggested by H. Forssman and G. Hambert [*Lancet* **1966-II**, 282 (1966)].
70. G. W. Fenton, T. B. Tennent, K. A. Comish, N. Rattray, *Brit. J. Psychiat.* **119**, 185 (1971).
71. D. J. Bartlett, W. P. Hurley, C. R. Brand, E. W. Poole, *Nature* **219**, 351 (1968).
72. E. W. Poole, in *Criminological Implications of Chromosome Abnormalities*, D. J. West, Ed. (Institute of Criminology, Cambridge, England, 1969), p. 68; ———, M. Beauchamp, I. Booth, M. Storm, *Electroencephalogr. Clin. Neurophysiol.* **29**, 326 abstr. (1970).
73. W. H. Sweet, F. Ervin, V. A. Marks, in *Aggressive Behavior*, S. Garrattini, Ed. (Wiley, New York, 1969), p. 336. The behavior of some XYY's seems similar to that described here [see J. Cowie and J. Kahn, *Brit. Med. J.* **1968**, 749 (1968)], but others appear to have more diffuse behavioral involvement.
74. D. A. Edwards [*Science* **161**, 1027 (1968)] has suggested that in adult mice "the usually observed sex difference . . . with respect to fighting is due to the fact that males are stimulated with testicular androgens early in life."
75. Six of seven XYY's detected in a study of mentally disordered sex offenders (*50*) may

have had a relatively early onset of puberty (*51*) in that sexual interest, seminal emissions, and secondary sex characteristics, as recalled by the patients or their parents (or both) first appeared around 9 to 10 years of age (*51*). There are, however, no data on XY's in the same setting. Two mentally ill, criminally insane XYY's in the same institution did not have such a history.

76. If a bell-shaped curve characterizes (physiologic) predisposition to deviance in XY's (with greater predisposition to the right on the horizontal axis and numbers affected on the vertical axis), the continuum hypothesis would predict for XYY's the same shape to the curve but a shift to the right, whereas the threshold hypothesis would predict a curve with original mode but with shoulder or second peak on the right. Neither alternative necessarily excludes the importance of environmental factors.
77. A. W. Griffiths, *Brit. J. Psychiat.* **119**, 193 (1971).
78. At Atascadero (*50*) the average IQ of nine XYY's was "slightly but not markedly lower" than that of a group of 184 XY men in the same cytogenetic study (*51*). The trend was present in both verbal and performance scores. But on the Minnesota Multiphasic Personality Inventory, Draw-a-person, and California Psychological Inventory evaluations, there were no significant differences between these two groups (*51*).
79. K. Hope, A. E. Philip, E. Philip, J. M. Loughran, *Brit. J. Psychiat.* **113**, 1195 (1967). This report compared seven of the nine XYY's studied by Price and Whatmore (*46*), with 11 of their 18 controls, so that the XY's were likely to have been both taller and more intelligent than the XYY's.
80. A. J. Little, unpublished result cited by McKerracher (*49*).
81. Nine XYY's at Carstairs (*45*) had committed proportionately more crimes against property than against persons (as compared to 18 institutionalized controls), were less openly hostile, and had fewer violently aggressive outbursts; any implication drawn from this data must be tempered by the fact that the controls were notably shorter and brighter than the XYY's, although all subjects were classified as having severe personality disorders. At least the same trend concerning offenses was noted by Griffiths *et al.*, using a control group matched more closely by height but not by IQ (*27*). And Casey *et al.* (*48*) noted a slightly lower rate of nonsexual crimes against the person by 33 XYY's, compared to 154 random XY controls in the same settings, but a slightly higher rate of sexual offenses [including, apparently, sexual aggression (*49*)] and a greater rate of absconding and crimes against property. However, Daly (*56*) found that among 10 XYY individuals compared to 54 (tall) controls "whose psychiatric and criminal historical records were comparable in quantity and quality to those available for the XYY patients" there was no difference in the frequency of stealing, nonsexual physical violence, and heterosexual offenses. But there was a significantly greater incidence of homosexual behavior in XYY's. Griffiths *et al.* noted homosexual tendencies in three of nine XYY's, but in no XY control prisoners. Furthermore if XYY's have been committed to custody in part because of channeling due to large size (that is, because officials have viewed them as greater threats because of their greater height), then on the whole they should have committed fewer significant offenses than shorter XY's and should provide less serious problems in custody. Furthermore, in this event one might also expect the shorter XYY's in custody to have more serious criminal histories than the taller XYY's. There are not yet enough data to answer this question.
82. The hypothesis of "impulsivity" as the "key" to the behavioral disorder has been suggested by J. Money [*Semin. Psychiat.* **2**, 11 (1970)].
83. If the true fraction in mental-penal settings is less (for example, 1/1000), the risk is less (2 percent); if greater (1/200), the risk is greater (9 percent).
84. F. A. Baughman and J. D. Mann, *Excerpta Med. Int. Congr. Ser.*, No. 233 (1971), p. 23.
85. F. A. Baughman, personal communication.
86. S. Wright, B. F. Crandall, L. Boyer, *Perspectives in Cytogenetics* (Thomas, Springfield, Ill., in press).
87. The rate of sex chromatin–positive males provides only an upper bound on the number of XXY's since other genotypes such as XXYY, XXXY, and XXY/XY, are also compatible with positive sex chromatin and Klinefelter's syndrome. But in at least three studies cytogenetic analyses have been done as well. Maclean *et al.* [(cited by Court-Brown (*88*)] found 15 XXY's in 13,947 newborns in the United Kingdom (as well as 6 XXY/XY's, 1 XXYY, and 1 XX male). Four sex chromatin–positive males were not studied, and thus the rate of XXY's was between 0.11 percent and 0.14 percent. Eller *et al.* (*89*) in Denver found 8 XXY's in 10,805 male newborns (0.07 percent) and 1 XXY/XY mosaic. Bell (*44*) in Toronto detected 40 conceptions which resulted in XXY's in study of 37,429 newborn males (0.11 percent) as well as one XXYY and one XXY/XY.
88. W. M. Court-Brown, *Int. Rev. Exp. Pathol.* **7**, 31 (1969).
89. E. Eller, W. Frankenburg, M. Puck, A. Robinson, *Pediatrics* **47**, 681 (1971).
90. The uncertainty is because two sex chromatin–positive males did not have chromosome studies. The rate of XXY's was about the same in the group with IQ's of 20 to 49 as in the group with IQ's of more than 50.
91. In the 11 studies for which exact rates are available, the frequencies are 21 in 2448 whites and 5 in 1911 blacks. See also (*34*) for data on some particular studies.
92. On the average XXY's are taller than XY's but do not appear to have a higher frequency of acne. Hypogonadism seems unlikely to account for antisocial behavior in XXY's, as judged from comparisons with hypogonadal XY men [D. D. Federman, *Abnormal Sexual Development* (Saunders, Philadelphia, 1967), p. 30; J. Nielsen, A. Sorenson, A. Theilgaard, A. Froland, S. G. Johnsen, *Acta Jutlandica* **41** (3), 1 (1969)].
93. See (*94*) (on XYY) and (*89*) (on XXY) for different approaches to this problem.
94. G. H. Valentine, M. A. McClelland, F. R. Sergovich, *Pediatrics* **48**, 583 (1971).
95. There is suggestive evidence that the likelihood of an XYY fathering an XYY son is less than the risk that might be theoretically expected (*47*), but is likely to be greater than that for an XY father (*96*).
96. R. B. Diasio and R. H. Glass, *Lancet* **1970-II**, 1318 (1970); M. Hulten and P. L. Pearson, *Ann. Hum. Genet.* **34**, 273 (1971).
97. See *Georgetown Law Rev.* **57**, 892 (1969) for further discussion of legal implications. I know of no case in the United States where the presence of an XYY genotype has been admitted as evidence pertaining to an "insanity" defense, despite several such attempts.
98. At least one such episode has already occurred. The mother was told of what little was known of the prognosis at the time of the procedure and elected to abort the fetus (H. L. Nadler, personal communication).
99. For evidence consistent with the existence of such see F. Schulsinger, *Int. J. Ment. Health* **1**, 199 (1972).
100. S. Walzer, C. Breau, P. S. Gerald, *J. Pediat.* **74**, 438 (1969).
101. F. Sergovich, G. H. Valentine, A. T. C. Chen, R. W. H. Kinch, M. S. Smout, *N. Engl. J. Med.* **280**, 851 (1969).
102. P. E. Conen, personal communication.
103. J. Hamerton, personal communication.
104. J. H. Turner and N. Wald, in *Human Population Cytogenetics*, P. A. Jacobs, W. H. Price, P. Law, Eds. (Edinburgh Univ. Press, Edinburgh, 1970), p. 153.
105. J. H. Turner, personal communication.
106. Recherche Cooperative Sur Programme No. 85 (CNRS), *Ann. Genet.* **11**, 245 (1969).
107. J. Nielsen, T. Tsuboi, B. Tuver, J. T. Jensen, J. Sachs, *Acta Psychiat. Scand.* **45**, 402 (1969).
108. J. A. Edwards, personal communication.
109. J. Aitken, M. Brunton, P. A. Jacobs, W. H. Price, K. MacColl, *Clin. Genet* **2**, 338 (1971). Table 3 of this reference implies that all five men with sex chromosome abnormalities at this institution might be considered as in a mental-penal setting, not just the three listed in my Table 3.
110. P. A. Jacobs, W. H. Price, S. Richmond, R. A. W. Ratcliff, *J. Med. Genet.* **8**, 49 (1971).
111. R. J. Davis, B. J. McGee, J. Empson, E. Engel, *Lancet* **1970-II**, 1086 (1970).
112. H. Hubner, *Bull. Acad. Polit. Sci.* **19**, 467 (1971).
113. B. Noel, B. Quack, Y. Durand, M. O. Rethore, *Ann. Genet.* **12**, 223 (1969).
114. B. F. Crandall, R. E. Carrel, R. S. Sparks, *J. Pediat.* **80**, 62 (1972); B. F. Crandall, personal communication.
115. M. D. Casey, C. E. Blank, D. R. K. Street, L. J. Segall, J. H. McDougall, P. J. McGrath, J. L. Skinner, *Lancet* **1966-II**, 859 (1966); M. D. Casey, personal communication.
116. J. Nielsen, G. Sturup, T. Tsuboi, R. Romano, *Acta Psychol. Scand.* **45**, 383 (1969).
117. Results of P. Behr, B. Noel, B. Quack, cited by Noel *et al.* (*113*).
118. R. A. Pfeiffer, G. Riemer, W. Schneller, *Med. Welt* **69**, 75 (1969).
119. R. M. Goodman, W. S. Smith, C. J. Migeon, *Nature* **216**, 942 (1967).
120. Results of Wiener *et al.* cited in (*47*). See also S. Wiener, G. Sutherland, A. A. Bartholomew, B. Hudson [*Lancet* **1968-I**, 150 (1968)] for further comments on the ascertainment criteria.
121. H. Hunter, *Lancet* **1968-I**, 816 (1968).
122. S. J. Knox and N. C. Nevin, *Nature* **222**, 596 (1969).
123. A. R. Falek, R. Craddick, J. Collum, *J. Nerv. Ment. Dis.* **150**, 165 (1970).
124. A. M. Marcus and G. Richmond, *J. Foren. Sci.* **15**, 154 (1970); A. M. Marcus, personal communication.
125. W. D. Fattig, *J. Hered.* **61**, 10 (1970).
126. A. Asaka, E. Inouye, T. Kayaba, M. Honma, *Lancet* **1971-II**, 985 (1971).
127. H. O. Akesson, H. Forssman, L. Wallin, *Acta Psychiat. Scand.* **45**, 37, 1969.
128. H. G. Close, A. S. R. Goonetilleke, P. A. Jacobs, W. H. Price, *Cytogenetics* **7**, 277 (1968).
129. L. R. Shapiro, *Lancet* **1970-I**, 623 (1970); personal communication.
130. J. D. Murken and D. Kunze, *Monatsschr. Kinder.* **119**, 366 (1971).
131. A. A. Bartholomew and G. Sutherland, *Med. J. Austral.* **2**, 440 (1969). This study provided some difficulty in classification. The 47 nonalcoholic, nondrug-dependent men were apparently chosen because they were psychopathic, and tall or of dull intelligence (or both). The study of this group has been conservatively classified as indeterminate mental-penal and listed in Table 6. Selection for tall men may also have occurred in the group of 92 alcoholics studied, and this group is therefore also categorized as indeterminate and listed in Table 6. All sex chromosome abnormalities were among the 42 who were serious offenders and "alcoholics simpliciter." There were none among the 36 who were just "drunk and disorderly" or among the 14 serious offenders who were also drug-dependent. The alcoholic stated to have "an additional autosomal abnormality" is 47 XYYDp+ [S. Wiener, G. Sutherland, A. A. Bartholomew, *Aust. N. Zealand J. Criminol.* **2**, 20 (1969) and classified in Table 6 as XYY]. In an addendum another 21 individuals are said to have been studied, and an XXY (alcoholic) and XYY (treated schizophrenic) were detected. Since selective or diagnostic criteria for the 21 in this study are not specified, I have not included it in any of the tables, although it might be regarded as a positive mental-penal study.
132. G. Sutherland and A. A. Bartholomew, *Aust. N. Zealand J. Criminol.* **3**, 99 (1970).
133. E. de Toni, M. G. Vianello, G. Serra, B. Baglietto, *Minerv. Pediatr.* **23**, 697 (1971).
134. L. Buentello and S. Armendares, *Rev. Invest. Clin.* **22**, 257 (1970).
135. R. Dussault, M. L. Destine, L. Dallaire, *Can. Psychiatr. Ass. J.* **16**, 253 (1971).
136. C. Zavella, G. Mora, R. Lisker, *Rev. Invest. Clin.* **22**, 251 (1970).
137. J. Kahn, W. I. Carter, N. Dernley, E. T. O. Slater, in *Criminological Implications of Chromosome Abnormalities*, D. J. West, Ed. (Institute of Criminology, Cambridge University, Cambridge, England 1969), p. 44.
138. V. Mekanandha and S. Bampotkasem, *J. Med. Ass. Thailand* **55**, 32 (1972).
139. I am indebted to those cited for their personal communications and the many colleagues who read the manuscript at various stages for their comments. I thank S. Selvin for advice on statistical matters.