

ability to release ACTH and β -endorphin), we synthesized [Leu¹², Glu¹³] α -helical CRF residues 9 to 41, which was found to be equipotent to the standard in its ability to inhibit oCRF-induced ACTH release in vitro (Table 1). To obtain more chemically stable antagonists, we also synthesized the Nle-substituted analogs at positions 18 and 21 of our α -helical CRF residues 8 to 41 and 10 to 41. These two analogs were found to be less potent than our standard.

The results of five independent experiments showed that the standard antagonist, α -helical CRF residues 9 to 41, blocked the secretion of ACTH that was stimulated by a 1-nM dose of CRF by 50 percent (197 ± 72 nM) (Fig. 1A). This inhibition was specific because the standard antagonist had no effect on the growth hormone-releasing factor-stimulated secretion of growth hormone, the gonadotropin-releasing factor-stimulated secretion of leuteinizing and follicle stimulating hormones, the thyrotropin-releasing factor-stimulated secretion of thyrotropin and prolactin, or the secretion of ACTH induced by another secretagogue, phorbol myristate acetate. Several lines of evidence suggest that the antagonists acted by competing with CRF for binding to its receptors. The antagonists caused a parallel rightward shift in the CRF dose-response curves. Higher concentrations of CRF would completely overcome the blockade of the action of lower concentrations of CRF (Fig. 1B). The CRF antagonists could compete with an iodinated CRF analog for binding to anterior pituitary membranes (23).

The CRF antagonists were tested for their effects on the spontaneous release of ACTH in adrenalectomized rats. An intravenous injection of 1 mg of CRF antagonist (0.6 μ mole per kilogram of body weight) caused a decrease in plasma ACTH amounts [measurements were performed as described (1)] that was statistically significant for 2 hours (Fig. 2). In the intact, nonanesthetized rats, the antagonist inhibited CRF-induced ACTH secretion in a dose-dependent manner that was significant at the 0.02- μ mole dose (Fig. 4). This antagonist also prevented most, but not all, of the increase in ACTH caused by ether-exposure (Fig. 4).

These results indicate that administration of CRF antagonists reduces the spontaneous ACTH release observed after removal of the corticosteroid feedback, blocks the ACTH secretion caused by CRF, and inhibits most of the stressor-induced ACTH release in intact rats. These data are comparable to those ob-

tained earlier in our laboratory with an antiserum to CRF (2) and further support the idea of a physiological role of endogenous CRF in regulating ACTH secretion. In addition, other studies (24) have shown that CRF antagonists can partially block the ether-exposure-induced activation of the sympathetic nervous system (9) and suggest a broader role for this neuropeptide in mediating the response to stressful stimuli.

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Genetic Influences in Criminal Convictions: Evidence from an Adoption Cohort

Abstract. *The possibility that genetic factors are among the causes of criminal behavior was tested by comparing court convictions of 14,427 adoptees with those of their biological and adoptive parents. A statistically significant correlation was found between the adoptees and their biological parents for convictions of property crimes. This was not true with respect to violent crimes. There was no statistically significant correlation between adoptee and adoptive parent court convictions. Siblings adopted separately into different homes tended to be concordant for convictions, especially if the shared biological father also had a record of criminal behavior.*

This study of the role of genetic factors in the etiology of criminal behavior is based on a register of 14,427 nonfamilial adoptions in a small northern European nation between 1927 and 1947. The register was established by a group of American and European investigators (1) and includes information on the adoptee and his or her adoptive and biological parents.

Court convictions were used as an index of criminal involvement. The data exclude minors below the age of 15, who are exempt from court convictions. Court records were obtained for all persons for whom data and place of birth were available ($N = 65,516$). The sub-

jects' occupations permitted the coding of socioeconomic status (2).

Cases were excluded from the study if there was no record of place or date of birth, if the identity of the biological father could not be established, if the adoption was by a single woman, or if the birth date was prior to 1 January 1895. Exclusion of an adoptee resulted in exclusion of the entire adoptive family but, if a parent was excluded, the remaining subjects were retained for analysis. Data on individuals not fully identified are shown in Table 1.

Conviction rates of completely identified members of the adoptee families are also shown in Table 1. Rates for biologi-

Table 1. Conviction rates of completely identified members of adoptee families.

Family member	Number identified	Number not identified	Conviction rate by number of convictions			
			0	1	2	> 2
Male adoptees	6,129	571	0.841	0.088	0.029	0.049
Female adoptees	7,065	662	0.972	0.020	0.005	0.003
Adoptive fathers	13,918	509	0.938	0.046	0.008	0.008
Adoptive mothers	14,267	160	0.981	0.015	0.002	0.002
Biological fathers	10,604	3,823	0.714	0.129	0.056	0.102
Biological mothers	12,300	2,127	0.911	0.064	0.012	0.013

cal fathers and male adoptees are considerably higher than those of adoptive fathers. The adoptive father rate (8 percent) is a bit below that of the population average for men of the same age range and time period (3). Most of the adoptive fathers convicted of criminal activity were one-time offenders, while male adoptees and their biological fathers were more heavily recidivistic.

Conviction rates of the women in the three categories are lower than those of the men but follow the same pattern. Adoptive mothers are just below the population average for women of this age range and time period (2.2 percent) with respect to rate of conviction (4).

In most of the analyses that follow, the relation between parent and adoptee court convictions will be considered. If either mother or father (biological or adoptive) had a court conviction, the parents for that adoptee will be considered criminal. In view of the low number of convictions among female adoptees, analyses will concentrate on male adoptees.

The size of the population permits segregation of subgroups of adoptees with combinations of convicted and non-convicted biological and adoptive parents in a design analogous to the cross-fostering model used in behavior genetics. If neither the biological nor the adoptive parents are convicted, 13.5 percent of the sons are convicted. If the adoptive parents are convicted and the biological parents are not, this figure rises only to 14.7 percent. However, if the adoptive parents are not convicted and the biological parents are, 20.0 percent of the sons are convicted. If the adoptive parents as well as the biological parents are convicted, 24.5 percent of the sons are convicted. These data favor the assumption of a partial genetic etiology. However, simply knowing that an adoptive parent has been convicted of a crime does not reveal how criminogenic the adoptee's environment has been (5). At conception, the genetic influence of the biological father is complete. This is not a fair comparison between environmental and

genetic influences but indicates only that sons whose biological parents have court convictions for criminal offenses have an increased probability of becoming convicted. Adoptive parent criminality was not found to be associated with a statistically significant increment in the son's criminality, but the effect of biological parent criminality was. A log-linear model, when only the additive effects of the biological parents and the adoptive parents is considered, shows that these two factors leave almost no room for improvement of the model fit by interaction effect.

The relation between criminal law convictions in the sons and degree of recidivism in the biological parents (6) is positive and relatively monotonic (Fig. 1). A log-linear analysis shows a statistically significant relation for property crimes but not violent crimes. The chronic offender is infrequent but commits a markedly disproportionate number of crimes. This high rate of offending suggested the hypothesis that genetic predisposition plays a substantial role in these cases.

In one U.S. birth cohort study (7), the chronic offender was defined as one who

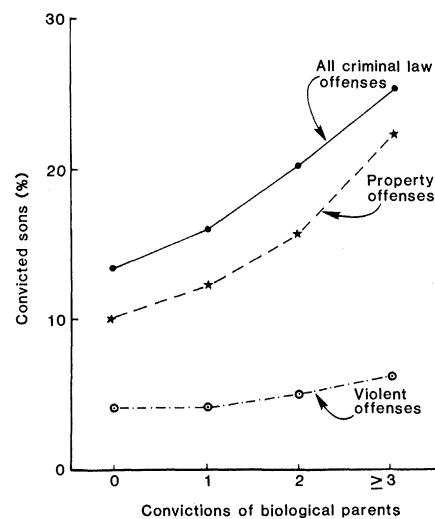


Fig. 1. Percentage of adoptees convicted of violent and property offenses as a function of biological parents' convictions (6).

had been arrested five or more times; these chronic offenders, who consist of 6 percent of the males, had committed 52 percent of the offenses. In our adoption cohort we recorded court convictions rather than arrest data. If we select as chronic offenders those with three or more court convictions, they were 4.09 percent of the male adoptees. This small group of recidivists accounts for 69.4 percent of all court convictions for all the male adoptees, a high concentration of crime in a small fraction of the cohort.

Table 2 shows how chronic offenders, other offenders (one or two convictions), and nonoffenders are distributed as a function of amount of crime in the biological parents. The proportion of chronic adoptee offenders increases as a function of recidivism in the biological parents. Note, however, that a genetic influence is not sufficient to produce criminal convictions in the adoptee. Of those adoptees whose biological parents have three or more convictions, 75 percent never received a court conviction. Another way of expressing this concentration of crime is that the chronic male adoptee offenders with biological parents having three or more offenses number only 37. They make up 1 percent of the 3,718 male adoptees in Table 2 but are responsible for 30 percent of the male adoptee convictions. The mean number of convictions for the chronic adoptee increases sharply as a function of biological parent recidivism.

There are instances where a biological mother, a biological father, or both contributed more than one child to this population. Some of these children, who were full or half-siblings, were placed in different adoptive homes. The probability of any one male adoptee's being convicted is 0.159; the probability of at least one of a pair of unrelated, separated male adoptees' being convicted is 0.293. The probability of both of a pair's being convicted is 0.025. Thus the concordance rate for pairs of unrelated, separated male adoptees is 8.5 percent. This can be viewed as a baseline.

There were 126 male-male half-sibling pairs placed in separate adoptive homes. Of these, 31 pairs had at least one member of the sibship convicted, and of these 31 pairs, 4 pairs were concordant for convictions—a concordance rate for half-siblings of 12.9 percent. There were 40 male-male full sibling pairs placed in different adoptive homes. Of these, 15 pairs had at least one member of the sibship convicted; of these 15 pairs, 3 pairs were concordant for convictions—a concordance rate for full siblings of 20

percent. The numbers are small but indicate that as the degree of genetic relationship increases, the level of concordance increases.

Of 98 biological fathers with at least one pair of male-male separated adoptee children, 45 had received at least one court conviction (8). Of the 45 sibling pairs (half and full sibs) contributed by these fathers, 13 pairs had at least one member with a court conviction; of these 13 pairs, 4 pairs were concordant for convictions—a concordance rate of 30.8 percent (9). The results suggest that a number of these separated adoptee siblings inherited some characteristic that made both vulnerable to criminal behavior. In those instances in which the biological father is criminal, the effect is enhanced.

Convictions of females for criminal law violations are infrequent (Table 1). Perhaps women whose criminal behavior prompts a court conviction have a predisposition for such behavior. Criminal involvement in many men, on the other hand, may be more socially or environmentally induced. It is possible, therefore, that criminal behavior in the biological mother will be more closely related to the adoptees' convictions than criminal behavior in the biological father.

In all our analyses, the relation between biological mother conviction and adoptee conviction is significantly stronger than that between biological father and adoptee convictions. In comparison to the biological fathers, crime in the biological mothers is more closely related to crime in the daughters. This result is statistically significant, but in view of the relatively low frequency of female convictions, the findings must be interpreted with caution.

We have previously reported (10) the variance ascribable to "genetic" social class and "rearing" social class, examining adoptee crime as a joint function of biological parents' social class and adoptive parents' social class. Male adoptee crime varied as a function of both genetic and environmental social class; log-linear analyses revealed both effects to be statistically significant. Our finding that environmental aspects of social class life influence the relation between social class and crime suggests that regardless of genetic background, improved social conditions are likely to lead to reductions in criminal behavior.

There is also a correlation between adoptive parent socioeconomic status (SES) and biological parent SES, representing an attempt by the adoption agency to match certain characteristics of the

Table 2. Proportion of chronic offenders (≥ 3 convictions), other offenders (1 or 2 convictions), and nonoffenders in male adoptees as a function of number of convictions in the biological parents. Cases in which adoptive parents have been convicted of criminal law violations are excluded.

Male adoptee convictions	Biological parent convictions			
	0	1	2	≥ 3
None	0.87	0.84	0.80	0.75
1 or 2	0.10	0.12	0.15	0.17
≥ 3	0.03	0.04	0.05	0.09
Number of adoptees	2492	574	233	419

two sets of parents. However, the relation between biological parent and adoptee criminal convictions exists at each level of adoptive parent SES. Stepwise multiple regression analyses, which varied the order of entry of biological parent convictions and SES and adoptive parent convictions and SES, indicate that independent of SES, biological parent criminality is significantly related to adoptee criminality.

Before generalizations can be made, biases introduced by loss of subjects in specific analyses should be considered (Table 1). In addition, the transfer history of the adoptees, as well as the possible effects of labeling of adoptee children of convicted biological parents, should be considered.

First, our consideration of characteristics of those not fully identified suggests that their inclusion would not have altered the nature of the results presented here. Perhaps the most critical facts in this judgment are that the adopted-away sons of parents not fully identified have levels of criminal law convictions and rearing social status that are approximately the same as for the sons of those parents fully identified. The observed differences are small; it is difficult to formulate any manner in which the lost subjects might have had an impact on the findings reported.

Second, among the adoptees, 25.3 percent were placed immediately in an adoptive home; the remainder were placed in orphanages. Of those placed in orphanages, 50.6 percent were placed with an adoptive family in the first year, 12.8 percent in the second year, and 11.3 percent after the age of 2. Analyses showed that age of transfer did not interact with genetic influence so as to alter significantly the relation observed with the full population (11).

Third, prospective adoptive parents were routinely informed about criminal

convictions of biological parents. This information could result in the labeling of the adoptee and affect the likelihood that the adoptee would commit criminal acts. Of the convicted biological parents, 37 percent had their first conviction before the adoption; thus the adoptive parents were likely to be informed of the conviction. In 63 percent of the cases, the first conviction of the biological parent occurred after the adoption; in these cases the criminality information was not transmitted to the adoptive parents. In cases in which the biological parent was first convicted before adoption, 15.6 percent of the male adoptees received convictions. In cases in which the biological parent was first convicted after the adoption, 16.1 percent of the male adoptees received convictions. The conviction rate of female adoptees was 4 percent in each group. A similar result was obtained by studying the effect of timing of the initial arrest of the biological father (12). The fact that the adoptive parents were informed of the biological parents' criminality did not alter the likelihood that the adoptive son would be convicted of a crime.

In summary, in a population of adoptions a relation was found between biological parent criminal convictions and criminal convictions in their adoptee children. No evidence was found that type of crime of biological parents was related to type of adoptee crime. A number of potentially confounding variables were considered; none proved sufficient to explain the genetic relation. We conclude that some factor transmitted by criminal parents increases the likelihood that their children will engage in criminal behavior. This claim holds especially for chronic criminality. The findings imply that biological predispositions are involved in the etiology of at least some criminal behavior.

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6. Only cases in which neither adoptive parent is convicted were included. In view of the low frequencies of court convictions and recidivism among the adoptive parents and in order to simplify interpretation, analyses include only cases in which adoptive parents have no criminal law convictions.
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Directional Specificity in the Regeneration of Lamprey Spinal Axons

Abstract. After spinal transection in ammocoetes (lamprey larvae) 4 to 5 years old, functional recovery is accompanied by a limited regeneration in which axons grow as far as 5 millimeters beyond the scar. In axotomized giant interneurons labeled intracellularly with horseradish peroxidase 16 to 120 days after transection, 74 percent of regenerating neurites grew in their normal projection pattern, rostral and contralateral to the cell body. One third of the neurites originated anomalously from posterior dendrites. Despite their initial abnormal orientation, 80 percent of these neurites looped contralaterally and rostrally to assume the normal projection path. The directional specificity persisted when giant interneurons were located in islands formed by double simultaneous cord transection. This limited regeneration seems to be characterized by directional selectivity that cannot be attributed to nonspecific influences, such as a tendency of neurites to grow in an already established direction or a trophic effect of the zone of injury.

Mammalian central nervous system axons can be induced to grow into peripheral nerve bridges and to regenerate 1 or 2 mm into the nervous system at the distal end (1). Such limited axonal regeneration may be useful as an approach to the treatment of spinal cord injury. In contrast to the target-specific regeneration seen in the retinotectal system of lower vertebrates (2), however, little is

known about the rules governing this growth. In particular it is not known whether such growth is directionally specific.

The transected spinal cords of several lower vertebrates show such a limited form of axonal regeneration accompanied by behavioral recovery (3, 4). We have studied the spinal cord of ammocoetes (sea lamprey larvae) 4 to 5 years

old because identified cells and axons with known projection patterns can be injected with tracers and their regenerating neurites studied in whole-mounted preparations (5, 6).

During the first 2 weeks after spinal transection in lamprey larvae, cut axons die back as far as 2 mm (6, 7) or more and then sprout, elongate, or both. Fibers grow no further than a few millimeters beyond the scar, and most fibers do not reach their original targets (4, 6). Abnormal directions of neurite growth have also been described in these studies. Thus, it is not yet known whether this limited regeneration is characterized by a specificity in the direction of neurite growth or, alternatively, whether fibers crossing the scar represent only a subpopulation of randomly sprouting neurites. We have now determined the position and orientation of the distal ends of 46 regenerating neurites in 27 axotomized giant interneurons regardless of whether they crossed the scar.

In the first experiments, larval sea lampreys 9 to 11 cm long had single spinal transections at the level of the cloaca (Fig. 1A) and recovered from 16 to 99 days. After this time giant interneurons located within 3.5 mm caudal to the transection scar were injected with horseradish peroxidase (HRP) (Fig. 1C), and whole-mounts of the spinal cords were prepared. Experimental methods and solutions have been described (4, 6).

The projection patterns for regenerating neurites is summarized in Table 1. Overall, 74 percent of the neurites projected rostralward in their normal position in the contralateral axon tracts (Fig. 2A). These findings might simply indicate that axons tend to grow in an already established direction. This simple explanation does not, however, account for our observations on 4 of 14 injected cells in animals with single transections and an additional four of nine cells in animals with double transections in which the axons died back completely and had not regenerated. In intact animals the axons of giant interneurons invariably originate anteromedially. Thus, the absence of an axon originating from the anterior side of some cells in animals with spinal transections indicated total retrograde degeneration. In these cells, one or more neurites grew out of posterior dendrites and were therefore initially oriented posteriorly. In spite of this initial incorrect orientation, eight of ten such neurites looped anteriorly and crossed the midline so that their growth was now oriented in the normal direction (Fig. 2B). Thus these

Table 1. Projection patterns of 46 neurites in 27 axotomized giant interneurons. The neurite projection is determined by the orientation of the distal end of the fiber. The normal projection of axons of giant interneurons is crossed and rostral. For neurons below a single transection and for those located in islands of spinal cord formed by double transections, the majority of neurites were oriented normally, even for neurites with posterior origins.

Neurite origin	Neurite projection	Transection		Total
		Single	Double	
Anterior (normal)	Rostral (normal)			
	Crossed (normal)	20	6	26
	Uncrossed (abnormal)	0	1	1
	Caudal (abnormal)			
	Crossed	9	0	9
Posterior or medial (anomalous)	Uncrossed	0	0	0
	Rostral			
	Crossed	5	3	8
	Uncrossed	0	1	1
	Caudal			
	Crossed	1	0	1
	Uncrossed	0	0	0