subsequently start to drink hard liquor, a few of the adolescents who start hard liquor right after beer and wine subsequently start to smoke. No youths in either cohort progress from beer and wine to illicit drugs without also taking up hard liquor or cigarettes on the way. Progression to marihuana appears predominantly among adolescents who have already used tobacco or hard liquor; the effects of the two are independent and additive.

The types of changes and the sequences in patterns of change are strikingly similar in both cohorts and are found in all grades in high school, in both sexes, and are independent of family educational background and race (data not presented).

Although the data show a clear sequence in drug use, a particular drug does not invariably lead to other drugs higher up in the sequence. Many youths stop at a particular stage and do not progress further; many regress to lower drugs. However, the data do establish that patterns of use are likely to follow certain paths. Four stages in progression are diagrammed in Fig. 1. Estimates of the proportion of youths progressing through each stage are based on data from the high school cohort (*9*). The model in Fig. 1 is supported by the fact that few drug users proceed to a drug at a particular stage without first trying the preceding one. In addition, different factors are related to drug use behavior at each of the stages (*10*). These stages are probably culturally determined. The extent to which they are can be determined only by comparative and cross-cultural studies.

The identification of these stages in drug use behavior has important implications for studying the factors that predict, differentiate, or result from drug use. Whereas most studies compare youths within a total population on the basis of their use or nonuse of a particular substance, my results suggest a different strategy. Since each stage represents a cumulative pattern of drug use and generally contains fewer adolescents than the preceding stage in the sequence, comparisons must be made among members of the restricted group of respondents who have already used the drug or drugs at the preceding stage or stages, and those who have not. Unless this is done, the attributes identified as apparent characteristics of a particular class of drug users may actually reflect characteristics important for involvement in drugs at the preceding level (*11*).

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References and Notes

1. For detailed critiques, see E. Goode, *Drugs in American Society* (Knopf, New York, 1972); L. Grinspoon, *Marihuana Reconsidered* (Harvard Univ. Press, Cambridge, 1971); B. Johnson, *Marihuana Users and Drug Subcultures* (Wiley, New York, 1973); J. Kaplan, *Marihuana—The New Prohibition* (New World, New York, 1970). The view that marihuana is the first drug in drug use is arbitrary and derives from the fact that other substances, such as alcohol and tobacco, often are not regarded as drugs, probably because they are legal. [H. Nowlis, *Contemp. Drug Prob.* **1**, 3 (1971–1972); National Commission on Marihuana and Drug Abuse, *Drug Use in America: Problem in Perspective*, (Government Printing Office, Washington, D.C., 1973)].
2. J. C. Ball, C. D. Chambers, M. Ball, *J. Crim. Law* **59**, 171 (1968); C. Chambers, *An Assessment of Drug Use in the General Population* (New York State Narcotic Control Commission, Albany, 1971); D. Glaser, J. A. Inciardi, D. V. Babst, *Int. J. Addict.* **4**, 145 (1969); B. Johnson, *Marihuana Users and Drug Subcultures* (Wiley, New York, 1973); L. Johnston, *Drugs and American Youth* (Survey Research Center, Michigan, 1973); M. A. Lavenhar, E. A. Wolfson, A. Sheffet, S. Einstein, D. B. Louria, in *Student Drug Surveys*, S. Einstein and S. Allen, Eds. (Baywood, Farmingdale, New York, 1972), p. 33; L. Robins, H. Darvish, G. Murphy, in *The Psychopathology of Adolescence*, J. Zubin and A. Freedman, Eds. (Grune & Stratton, New York, 1970), p. 159; R. Weppner and M. H. Agar, *J. Health Soc. Behav.* **12**, 10 (1971).
3. These stages involve movement from one type of drug use to another, and not movement (or increased involvement) within a specific drug class, as has been described for alcohol [E. M. Jellinek, *Q. J. Stud. Alcohol* **13**, 673 (1952)] or heroin [I. Chein, D. L. Gerard, R. S. Lee, E. Rosenfeld, *The Road to H* (Basic Books, New York, 1964); I. Alksne, L. Lieberman, L. Brill, *Int. J. Addict.* **2**, 221 (1967); A. Wickler, *Br. J. Addict.* **57**, 73 (1961)]. The specific number of stages that are identified is somewhat arbitrary and depends on the classification of drug behaviors considered in a particular analysis.
4. Usable questionnaires were obtained from 8206 adolescents at time 1 and 7250 at time 2. The samples at each wave have been weighted to reflect the variable probabilities of selection of schools and homerooms and the response rates in each school. The follow-up, after the students were graduated from high school, was carried out by mail and by telephone, and produced a response rate of 69 percent. By means of self-generated identification code numbers [D. Kandel, *Science* **181**, 1067 (1973)], 66 percent of the high school students sampled in the fall (time 1) could be matched to themselves in the spring (time 2), and 60 percent of the seniors surveyed in the spring (time 2) could be matched to themselves after graduation (time 3). Thus, legal and ethical considerations in drug research dictate the use of a record linkage scheme in which a substantial portion of the students surveyed cannot be matched to themselves over time. Since unmatched cases contain a higher proportion of drug users than matched ones, the high school panel sample from time 1 to time 2 was weighted to reproduce the frequency of marihuana use observed at time 1 in the total cross-sectional sample.
5. L. Guttman, in *Measurement and Prediction*, S. A. Stouffer, L. Guttman, E. A. Suchman, P. S. Lazarsfeld, S. A. Star, J. A. Clausen, Eds. (Wiley, New York, 1950), p. 60.
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7. The index of reproducibility reflects the ability of scale scores to predict the scores of individuals on each of the items included in the scale. The lower acceptable limit is .90 (*5*). The number of drug use responses classified as errors in the scale fell well within acceptable limits, as reflected in the high value (.98) of the index of reproducibility. The index of scalability adjusts the reproducibility criterion by the minimal and maximal degrees of reproducibility possible given the item marginals. The acceptable lower limit is .60 [H. Menzel, *Public Opinion Q.* **17**, 268 (1953)].
8. A very small group of former nonusers starts exclusively with cigarettes or hard liquor: 5 and 2 percent, respectively, in the high school cohort.
9. For those youths who start to use more than one legal drug within the follow-up periods, the order in which they try the various legal drugs is not known. These multiple legal drug starters were distributed into a sequential order on the assumption that the proportion using a particular legal drug first in that group within the follow-up interval reproduced the proportion of known exclusive starters of that drug.
10. D. Kandel, D. Treiman, R. Faust, E. Single, paper presented at the annual meetings of the American Sociological Association, Montreal, August 1974.
11. D. Kandel and R. Faust, *Arch. Gen. Psychiatry* **32**, 923 (1975).
12. This work was supported by National Institute on Drug Abuse research grant DA-00064. R. Faust participated in the earlier stages of the analysis. S. Paton assisted in the preparation of the tabulations. I thank E. Kandel for critical reading of the manuscript.

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Pattern Discrimination After Lesions of the Visual Cortex

Dru *et al.* (*1*) recently reported that "self-produced locomotion" during the interoperative interval between two-stage lesions of the "visual cortex" spared the capacity of rats to reacquire a preoperatively learned pattern discrimination. While we are inclined to agree that interoperative experience may be an important variable in recovery of function after serial lesions, we are concerned that the lesions that Dru *et al.* depicted in their report do not permit the conclusion that "recovery of pattern vision after sequential removal of visual cortex is probably a consequence of functional reorganization of brain areas not primarily responsible for visual capacity."

In our opinion, the largest and smallest lesions shown in their figure 1 represent damage to areas 2 and 7, possibly areas 1, 3, 4, and 39, and only the anterior portions of areas 17 and 18, according to the topography of Krieg (*2*). In any case, their figure appears to show considerable sparing of primary and secondary visual cortex. Furthermore, the classical criterion of demonstrating total degeneration of the lateral geniculate body was omitted from the study. As long ago as 1939, Lashley (*3*) showed that rats with only 2 percent of the geniculo-striate system intact could solve visual discrimination problems similar to the one employed by Dru *et al.*

Based on the evidence from Lashley's investigations, we find it difficult to accept the above-stated conclusion of Dru *et al.* There is sufficient evidence to indicate that recovery of function after serial lesions of structures of the central nervous system is a viable phenomenon (*4*); however, before concluding that "extravisual" structures take over the function of visual cortex, Dru *et al.* should present detailed evidence for complete degeneration of the lateral geniculate body. In addition, if they wish to demonstrate that their effect is related to *inter*operative experience, animals with

one-stage lesions and equivalent post-operative experience should be included for comparison. It might also be worth while to test intact rats given the same "interoperative" experiences as those animals with lesions, since restriction alone could produce temporary deficits in the performance of normal controls.

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While the concern of Lewis and Stein is understandable, I wish to point out the following facts. Posterior extension of cortical lesions was limited by the vascularity of each particular animal. A little-reported but very consistent finding of surgery in this area is hemorrhage of up to 25 percent of total vascular volume secondary to disruption of meningeal vessels and major venous tributaries. Posterior extension of lesions therefore varied among animals, and the variation extended across all groups. In the Lashley (*1*) article cited by Lewis and Stein, anterior lesion of the striate cortex resulted in the loss of all but 713 of the 34,000 neurons in the corresponding lateral geniculate nucleus. Comparable lesions in our animals resulted in elimination of all but 1200 to 2500 neurons. In our animals with more posterior lesions, as few as 250 neurons were spared. We thus remain content with our findings.

The conclusion of Lashley (*1*) as restated by Lewis and Stein, that rats with only 2 percent of the geniculo-striate system intact could solve visual problems similar to the one employed in our laboratory, was based on the results of one animal. More recent studies have demonstrated that pattern discrimination is dependent upon an intact visual cortex (*2*). Modern discrimination-testing equipment now controls for differences in luminance flux, and eliminates extraneous auditory and visual cues.

During initial design and fabrication of restraining devices, no type of restraining holder was ever found to affect later performance of normal animals on the aversive discrimination task.

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^{31}P NMR in Cancer Amended

In our recent report (*1*) we stated that, to the best of our knowledge, ^{31}P NMR had not been applied before to organ tissues. Since then we have become aware of a prior publication by Hoult *et al.* (*2*) on ^{31}P nuclear resonance in muscle. Priority for the first application of ^{31}P NMR in tissue therefore rightly belongs to these workers, our work being the first introduction of ^{31}P NMR into cancer research and cancer detection.

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