of organelles—the kinetosomes—reflects this in its ultrastructural organization.

Apart from the homology of microtrichia with flagella (which is apparently a suggestion not previously made in the literature), several important questions arise from these findings. One is whether there are kinetosomes in the numerous larger polytene cells of the fly and whether the possible loss, duplication, or modification of centriolar structures are important factors in the inability of polytene cells to divide. There has recently been renewed interest in the role of centrioles both in cell division and in the control of cell polarity (*3*), and it is in this respect that the findings reported here may have their greatest potential significance. A considerable amount is known about insect epidermal cells in general, and pattern formation has been (*4*) and continues to be (*5*) a primary concern. The findings reported here would be the first definite indication of ultrastructural organization reflecting intercellular positional relationships in the insect epidermis.

Cell dissociation and reaggregation studies have been carried out extensively with dipteran cells (*6*). Similar reaggregation studies, with special attention to kinetosome orientation in relation to the reestablishment of patterns by dissociated cells, may throw light on problems of cell recognition and pattern formation. Similarities are evident between the simple patterning of epidermal cells in a fly, described here, and the arrangements found in simple colonial flagellates. In *Volvox* the colony is integrated by cytoplasmic strands connecting the individuals; these individuals form hexagonal arrangements and, according to Gerisch (*7*), the cells are arranged in an orderly pattern with respect to (i) the plane of flagellar insertion (and hence of the flagellar bases), (ii) the plane of flagellar vibration, and (iii) the plane of cell division. Perhaps these are features characteristic of a basic pattern originating in the colonial flagellates and retained even in animals, such as the insects, in which motile flagella are lost but their basal bodies retained. Considerations of pattern formation in insects (*4, 5*) have not previously involved hexagonal cell arrangements or the presence of specifically orientated flagellar structures.

JOAN M. WHITTEN
Department of Biological Sciences, Northwestern University, Evanston, Illinois 60201

References and Notes

1. J. M. Whitten, *J. Morphol.* **127**, 73 (1969).
2. The inner or proximal ends of the kinetosomes have the typical "cartwheel" structure, consisting of a cylindrical hub and nine fine, slightly swirled spokes extending to the peripheral triplet fibrils.
3. J. D. Pickett-Heaps, *Cytobios* **3**, 205 (1971).
4. K. C. Sondhi, *Quart. Rev. Biol.* **38**, 289 (1963).
5. P. A. Lawrence, *Advan. Insect Physiol.* **7**, 197 (1970); ———, F. H. C. Crick, M. Monroe, paper presented at the fourteenth International Congress on Entomology, Canberra, 1972; *J. Cell Sci.* **11**, 815 (1972).
6. A. Garcia-Bellido, *Develop. Biol.* **14**, 278 (1966).
7. G. Gerisch, *Arch. Protistenk.* **104**, 292 (1959).
8. Supported by a grant from the National Science Foundation. Grateful acknowledgment is made to Dr. J. B. Wagner of the Technological Institute, Northwestern University, for the use of the Jeol JSM-V3 scanning electron microscope, and to J. Jacoby for operating it. Thanks are also due to B. Sedlak for help with the preparative procedures for transmission electron microscopy carried out on a Hitachi 11E microscope.

13 February 1973; revised 1 June 1973 ■

Adolescent Marihuana Use: Role of Parents and Peers

Abstract. *In order to examine the relative influence of parents and peers on marihuana use among adolescents, independent data have been obtained from adolescents, their parents, and their best school friends in a sample of secondary school students in New York State. The data indicate that drug use by peers exerts a greater influence than drug use by parents. Friends are more similar in their use of marihuana than in any other activity or attitude. Parental use of psychotropic drugs has only a small influence, mostly related to maternal use. Peer and parental influences are synergistic; the highest rates of marihuana usage are observed among adolescents whose parents and friends are drug users.*

A social interpretation of adolescent drug use has been proposed, according to which drug use on the part of the young is assumed to develop in response to parental consumption of psychoactive drugs (*1*). According to this view, adolescent use of illegal drugs is a juvenile manifestation of adult behavior. This hypothesis has received apparent support from surveys that suggest a relationship between use of illegal drugs by young people and use of legal psychoactive drugs by their parents (*2*). Adolescents who use marihuana, LSD, and other hard drugs are more likely to report that their parents use tranquilizers, amphetamines, or barbiturates. These conclusions have so far been based exclusively on the youths' perceptions of their parents' drug use, not on usage reported directly by the parents. I find, on the basis of parents' self-reports, that the relationship between parental and adolescent drug use in matched parent-adolescent dyads is reduced, although it is still positive. Peer influence on adolescent drug use is stronger than parental influence. Peer and parental influences are synergistic, however, and marihuana use occurs most frequently in triads in which both friend and parents are drug users.

This report is based on a survey in which independent data were obtained from adolescents, their parents, and their best school friends. The basic adolescent sample ($N = 8206$) is a multiphasic random sample representative of public secondary school students in New York State, drawn from 18 schools throughout the state. The sample selection was based on a two-stage sampling procedure involving the selection of (i) a stratified sample of high schools and (ii) a sample of students clustered by homerooms and stratified to represent the different grades within a high school. In fall 1971, structured, self-administered questionnaires were given in a classroom situation to a random sample of homerooms in 13 schools and to the entire student body in five schools. Therefore, in these five schools, it was possible to collect data from the student's best school friend so as to obtain a relational sample of matched student-friend dyads. Within each of the 18 schools, all homerooms were surveyed simultaneously. The student sample was weighted to reflect the variable probabilities of selection of schools and homerooms and the absentee factor in each school. Two to three weeks after a school was surveyed, a questionnaire was mailed to one parent of each student, alternately mothers and fathers. A maximum of three follow-up contacts were involved. Usable questionnaires were returned by 5574 parents or 61 percent of the initial group contacted. Since the behavior investigated is illegal, the respondents did not sign the questionnaires; identification of records was accomplished through the use of self-generated identification numbers (*3*). Using these codes, we were able to match 49 percent of all the students to their parents and 38 percent of the students in the five schools to their best school friends.

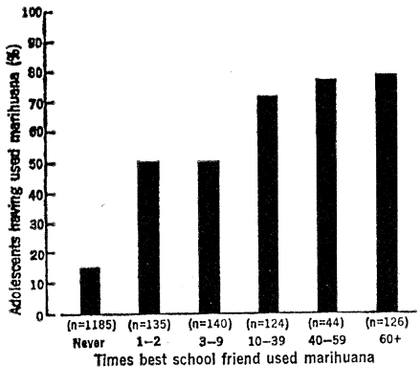

Fig. 1. Adolescent marihuana use correlated with self-reported marihuana use of best school friend. Dyads comprise students and best school friends in five schools, in fall 1971; *n*, number reporting.

In these five schools 1112 students, or 23 percent of those surveyed, could be matched to parents as well as to best school friends and were incorporated into triads. The resulting number of dyads and triads is below that obtained when matching is done on the basis of names (*4*). However, since these relational samples are used to analyze processes related to adolescent drug use, the loss of cases is less serious than it would be if the data were used to estimate incidence or prevalence rates of drug use in the New York State population. The findings presented in this report are based on the total sample of adolescents from the 18 schools, except when the self-reported behavior of friends is introduced, in which case the analyses are restricted to the 5-school sample.

Adolescents were asked about their use of a variety of illegal drugs and about their perceptions of their parents' use of psychoactive drugs. Parents were also asked about their own use of tranquilizers, barbiturates, or sedatives and stimulants (including diet pills and pep pills). I combined the answers for each class of drug to obtain a summary variable, parental use of any psychoactive drug.

Rather than examine a broad range of adolescent drug use, I focus in this report on marihuana, the illegal drug used most frequently by adolescents in our sample and in the population at large. In our sample of New York State high school students, 29 percent reported having used marihuana, the proportion increasing from the freshman (16 percent) to the senior class (41 percent). It should, however, be kept in mind that marihuana use overlaps with the use of other drugs. Marihuana users include a great variety of youths, ranging from "experimenters" who have tried the drug once or twice and have not tried other drugs (23 percent) to extensive users who have used marihuana many times (33 percent have used it 40 times or more) and have also used other drugs. The overwhelming majority (90 percent) of extensive marihuana users also take other drugs. In order to facilitate the analysis of interpersonal processes, I refer to marihuana use as if it were a simple behavioral entity. This simplification does not alter the basic results. Similar findings obtain when marihuana users are differentiated according to their frequency of use or whether or not they have also used other illegal drugs.

My findings confirm the previously reported association (*2*) between adolescents' drug use and the adolescents' perceptions of their parents' use of a variety of psychoactive drugs. Thus, 37 percent of adolescents are marihuana users among those who perceive their mothers to have used tranquilizers, compared to 24 percent among those who perceive their mothers to be nonusers. Furthermore, the proportion of adolescent users is directly related to the perceived frequency of parental use of psychotropic drugs. However, these relationships decrease when the actual reports of the parents on their psychotropic drug use are examined. Thus, 33 percent of adolescents use marihuana when their mother reports using tranquilizers, compared to 28 percent when she does not (*5*). For all types of parental psychoactive drug use, the associations of adolescent illegal drug use with parental self-reports are lower, by a factor of 2, than the associations with adolescent's perceptions of parental behavior. For example, the association of adolescent marihuana use with maternal use of any psychoactive drug is .083 [as measured by tau-beta, a measure of association for ordinal data (*6*)] when based on parental self-report, as compared to .161 when based on the child's perceptions.

The most striking finding is the crucial role which peers play in the use of drugs by other adolescents. Involvement with other drug-using adolescents is the most important correlate of adolescent marihuana use. Adolescents' marihuana use is strongly related not only to friends' perceived marihuana use but to the friends' self-reported use. Only 7 percent of adolescents who perceive none of their friends to use marihuana use marihuana themselves, in contrast to 92 percent of those who perceive all their friends to be users (*7*). When adolescent marihuana use is correlated with the self-reported marihuana use patterns

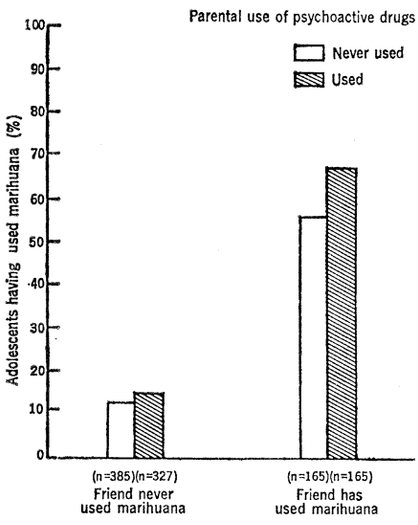

Fig. 2. Adolescent marihuana use correlated with self-reported marihuana use of best school friend and self-reported psychoactive drug use of parents. Triads are for five schools, in fall 1971; *n*, number reporting.

Table 1. Similarity within friendship pairs on selected attributes, as measured by tau-beta, a measure of association for ordinal variables (*6*). The dyads comprise students and best school friends in five schools, in fall 1971. The number of cases varies with each attribute because of differences in the number of students who did not answer particular questions.

Attribute	Tau-beta	Dyads (*N*)
Demographic characteristics		
Sex	.811	1873
Age	.686	1754
Ethnicity	.662	1469
Program in school	.267	1815
Religion	.166	1824
Drug behavior and attitudes		
Marihuana use	.487	1750
Smoking	.360	1822
Drinking alcohol	.294	1813
Number of friends reported to use marihuana or hashish	.463	1829
Attitude toward legalization of marihuana	.119	1856
Other activities and attitudes		
Overall grade average	.367	1855
Time spent on homework	.282	1856
Days absent from school	.187	1878
Getting together with friends	.240	1865
Attending religious services	.255	1782
Listening to records	.229	1802
Watching television	.155	1810
Political orientation	.175	1653

of best school friends (see Fig. 1), the proportion of users ranges from 15 percent when the best friend has never used marihuana to 79 percent when the friend has used it 60 times or more (*8*). Not only use per se, but extent of use, is highly related to friends' drug behavior. Thus, the proportion of adolescents who report having used marihuana 60 or more times increases from 2 percent among those whose friends have never used marihuana to 48 percent among those whose friends have themselves used the drug 60 times or more. The influence of best friends is extremely strong, but it is not the only influence. In addition to the 15 percent who are users when their best friend is not, 21 percent are nonusers despite the fact that the friend has used marihuana. Further analyses of deviant cases such as these may provide important insights into the circumstances under which adolescents do not respond to peer pressures.

Other data from the study document the extent to which experience with marihuana and with other drugs is a focus of interaction with peers and is closely related to the extent of involvement with peers. Indeed, we find that use of marihuana and of other illegal drugs is what friends have most in common. With the exception of certain demographic characteristics (such as age, sex, and race), on no other activity or attitude (such as school attitudes and performance, deviant behaviors of various kinds, political attitudes, drug-related attitudes, and attitudes toward parents) is similarity between friends as great as on illegal drug use (see Table 1).

The greater influence of friends than parents on adolescent marihuana use is illustrated further in the sample of matched triads when adolescent's marihuana use, best-school-friend's marihuana use, and parent's overall use of psychoactive drugs are examined simultaneously. While parents and best friends both have an independent effect on adolescents' marihuana use, the effect of peers is far larger than the effect of parents (Fig. 2). This is best seen in those triads in which the adolescent is exposed to conflicting role models because parent's and friend's behaviors diverge, one using drugs and the other not. When faced with conflict, adolescents are much more responsive to peers than to parents. Thus 56 percent of adolescents use marihuana when their best friends use marihuana although their parents have never used any psychoactive drugs. But only 17 percent of adolescents use marihuana when their parents have used psychoactive drugs but their best friends have not used marihuana. Parental influence can, however, synergize with and potentiate peer influence. The highest rates of adolescent marihuana use (67 percent) occur when both parent and peer reinforce each other's influence on the adolescent.

Parental drug behavior appears to be related to the child's use of illegal drugs only when such use already exists in the peer group. A necessary condition for the appearance of adolescent illegal behavior may be the use of illegal drugs by friends, parental use of psychoactive drugs being neither necessary nor sufficient for such adolescent behavior to develop. But given a situation in which peers use drugs, parental behavior becomes important in modulating peer influence. Children of non-drug using parents are somewhat *less* likely to use drugs, whereas children of drug using parents are *more* likely to use drugs.

These findings fit a "cultural deviance" model of behavior and in particular the theory of differential association developed by Sutherland and Crissey (*9*) to explain delinquent behavior. According to the theory, the crucial factor in the learning of delinquent roles by adolescents is the availability of delinquent role models in the adolescent peer group. The family can potentially lead the child toward delinquency, either because it engages in delinquent behavior which the child imitates, or because it creates a hostile climate from which the child seeks escape. But the child will not engage in delinquent acts unless such acts are present in the peer culture around him. This theory has been much debated since its formulation in 1939, and has often been held to be incorrect (*9, 10*). However, the present findings on illegal adolescent drug use appear to fit the the model. Peer behavior is the crucial determining factor in adolescent drug use and parental behavior becomes important once such behavior exists in the peer group.

Stressing the fact that an adolescent who uses drugs associates with other adolescent drug users does not answer the key question: Which comes first, drug use or drug-using friends? Do adolescents seek out drug users after they themselves have become involved with drugs or do they start using drugs because they come to associate with other drug-using friends? By using longitudinal data (across time) one might be able to provide answers to these questions.

DENISE KANDEL
Biometrics Research, New York State Department of Mental Hygiene, and School of Public Health, Columbia University, 722 West 168 Street, New York 10032

References and Notes

1. R. H. Blum *et al., Horatio Alger's Children: The Role of the Family in the Origin and Prevention of Drug Risk* (Jossey-Bass, San Francisco, 1972); H. S. Lennard, L. J. Epstein, D. B. Ransom, *Mystification and Drug Misuse* (Jossey-Bass, San Francisco, 1971); G. H. Mellinger, *J. Drug Issues* **1**, 274 (1971).
2. M. Lavenhar, E. A. Wolfson, A. Sheffet, S. Einstein, D. B. Louria, in *Student Drug Surveys*, S. Einstein and S. Allen, Eds. (Baywood, Farmingdale, N.Y., 1972), pp. 33–54; R. G. Smart and D. Fejer, *J. Abnorm. Psychol.* **79**, 153 (1972).
3. In each school, each adolescent was asked to construct a number for himself and, in the five schools, one also for his best friend in school, identical to the number the friend constructed for himself. Each parent was also asked to construct a number identical to the one the adolescent constructed for himself. The eight-digit self-generated numbers were based on the middle letters of the adolescent's first and last names, his date of birth, and the last two digits of his telephone number. Most adolescents (94 percent) and most parents (98 percent) were willing and able to construct self-generated numbers for themselves; 82 percent of adolescents constructed numbers for their friends. Some of the numbers produced were incorrect, incomplete, or, in the case of friends, for someone not in the school sample. However, individuals could often be matched even if some digits (phone numbers or friend's birth date) were missing.
4. See D. Kandel and G. S. Lesser, *Youth in Two Worlds* (Jossey-Bass, San Francisco, 1972), p. 190. The use of self-generated codes for linking questionnaires represents a compromise and is inferior to the use of names. Not only does it reduce the overall rate of matching, but it potentially introduces a bias in the resulting relational samples, since students who do not give a code number and cannot be matched contain a higher proportion of drug users than those who provide a code. Twenty-five percent of adolescents matched with a parent or best school friend or both have used marihuana, as compared to 35 percent of those not matched to either. However, because the relational sample of five schools is unweighed and two of these schools are large and in areas with high drug use, the overall rates of adolescent drug use are similar in the total representative adolescent sample and in each of the relational subsamples of dyads and triads.
5. Maternal influence is also greater on daughters than sons. To the extent that parental behavior has any influence at all, use of legal substances, such as alcohol, is more important than use of psychoactive drugs. But the overall effect of parental alcohol use on adolescent marihuana use is small (D. Kandel, in preparation).
6. M. G. Kendall, *Rank Correlation Methods* (Hafner, New York, 1962).
7. These findings confirm other surveys based exclusively on the youths' perceptions of their friends' behavior. B. Johnson, *Marihuana Users and Drug Subcultures* (Wiley, New York, 1973), chap. 4; National Commission on Marihuana and Drug Abuse, *Marihuana: A Signal of Misunderstanding* (Government Printing Office, Washington, D.C., 1972), Appendix, vols. 1 and 2; N. Tec, in *Student Drug Surveys*, S. Einstein and S. Allen, Eds. (Baywood, Farmingdale, N.Y., 1972), pp. 97–102.
8. Since in 79 percent of the cases, the adolescent's best friend in school is also the best friend outside school, the data permit infer-

ences about the role of best friends in general.
9. E. Sutherland and D. Cressey, *Criminology* (Lippincott, New York, ed. 8, 1970), pp. 75–91.
10. For a recent critique, see G. F. Jensen, *Amer. J. Sociol.* **78**, 562 (1972).
11. I thank E. Kandel, E. Single, and D. Wilder for critically reading the manuscript and R. Marel, S. Paton, and A. Weber for technical assistance. Supported by PHS research grant DA00064. A preliminary communication of these results was presented at the Conference on the Epidemiology of Drug Use, Puerto Rico, February 1973, sponsored by the Schools of Public Health of Columbia University and of the University of Puerto Rico and the National Institute of Mental Health.

24 April 1973; revised 8 June 1973

Curvature as a Feature of Pattern Vision

Abstract. *Prolonged inspection of convex lines of one color and concave lines of another color can cause the appearance of oppositely colored aftereffects in curved, achromatic test lines. These effects, strongly dependent on radius of curvature, cannot be attributed to tilt or orientation. It is concluded that these results are not encompassed by models of the visual system that are based on rectilinear arrays and that curvature is a specific feature of human visual perception.*

McCollough (*1*) described adaptational effects that were dependent on the orientations of lines. Her subjects viewed a horizontal grating of one color, alternating with a vertical grating of another color, for a total inspection time of 2 to 4 minutes. Following this inspection, relatively long-lasting, oppositely colored aftereffects appeared in achromatic gratings of the same orientations. McCollough pointed out that these aftereffects were not conventional afterimages, since they were governed only by the orientations of the lines. She suggested that these aftereffects might depend on "color adaptation of orientation-specific edge-detectors" and cited neurophysiological evidence that edges are particularly effective visual stimuli (*2*). She also pointed out similarities between her observations and those of Kohler (*3*) and others involving long-term adaptation to wearing prismatic spectacles that produced fringes of color along an edge. These studies had also shown relatively long-lasting, oppositely colored aftereffects along light-dark edges.

Harris and Gibson (*4*) confirmed McCollough's basic finding and gave additional evidence that retinal afterimages could not account for the effect. However, they questioned the need for a concept as complex as that of an "edge-detector." Instead they advanced a "dipole" hypothesis as a minimal construct to account for all the color-contingent aftereffects that had been observed up to that time. The dipole "would receive inputs from two nonconcentric areas of the retina. Given a population of fatiguable dipoles with some variation in spectral sensitivity and in spatial relation of receptive areas, very few additional assumptions are necessary to deal with all data on the McCollough effect" (*4*, p. 1507).

I have discovered that rectilinear arrays (straight lines and edges) are not a necessary feature of patterns that generate color-contingent aftereffects. Curved lines will do nearly as well, provided that opposite directions of curvature are used for the two inspection patterns, as shown in Fig. 1. This result would not be predicted by the dipole hypothesis as it was originally stated (*4*). Nor is it consistent with explanations based on detectors for orientation of lines or edges (*1–3*). Some alternative concept, such as that of detectors for curvature, is evidently called for.

To generate the effect, the observer first looked for a few seconds at the center of the red pattern in Fig. 1, then shifted his gaze to the center of the green pattern, and thus continued the alternate inspection of the two for a period of 40 seconds. The inspection patterns were then switched off, the achromatic test pattern was switched on, and the observer was asked whether any color difference seemed to be present from one panel to another of the test pattern. If no color effect was reported, the inspection stimuli were turned on again and inspected for an additional 20 seconds, after which another test with the achromatic pattern was given. This alternation of inspection and testing was continued in a logarithmic series of increasing durations for as long as was necessary to establish the colored aftereffect with this particular curvature. Six different curvatures were used, one per day in random order, with each of four subjects.

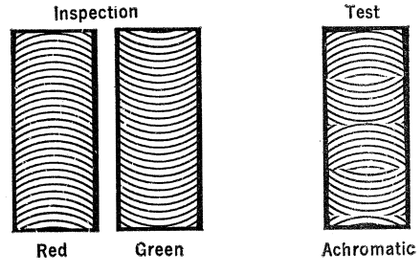

Fig. 1. Sample of inspection and test patterns used to evaluate curvature effects. The radius of curvature throughout this set of patterns is 4.5°. Note that the red inspection pattern has lines that are convex upward, and the green pattern has lines that are concave upward. After alternate inspection of these two patterns, the subject sees the corresponding curves on the test panels as greenish and pinkish, respectively. Each pattern is 13°8′ high and 5°26′ wide in angular subtense at the eyes with a viewing distance of 1 m. Patterns are on 35-mm slides projected through suitable red, bluish green, and achromatic dye filters so that the luminance of each pattern on the screen is approximately 6.8 mlam.

A summary of the individual results appears in Table 1 and median durations are plotted in Fig. 2. A "slight" effect was recorded when the observer reported that any panel of the test pattern had the appropriate appearance, namely, a coloration that was opposite to the one in the correspondingly curved lines during inspection. A "definite" effect was when the observer consistently reported that alternate test panels had the appropriate aftereffect colors. Note that there was relatively good agreement among the observers, and that the required inspection times were strongly dependent on radius of curvature.

It is clear that curvature-dependent colored aftereffects have been established. Brief inspections suffice to produce the effect with strong degrees of curvature, whereas inspection time rises steeply to 30 minutes or more as the lines approach a null condition in which they would all be straight and horizontal.

In a supplementary experiment, red and green patterns such as those shown in Fig. 1 were inspected for 15 minutes. At the end of that interval the entire series of six achromatic test patterns was presented together on the screen as shown in Fig. 3, and the subject was asked to rank them in order of the vividness of the colored aftereffects that appeared on each. Five subjects were used, and after a 15-minute inspection of strongly curved lines all of them rendered the expected judgment; namely, that more vividly colored aftereffects were seen on the test panels resembling those used for inspection than on those of weaker curvature. An unexpected result was obtained, however, on other