Table 1. Response to conservation, relational, and additive tasks; average percent correct for trials in a series. Transformation and static tasks were administered to two different sample groups. Transformation groups numbered: (1) 7; (2) 16; (3) 21; (4) 16; (5) 15. Static samples numbered: (1) 6; (2) 16; (3) 23; (4) 17; (5) 15. Additivity tasks were the same for both samples; these data are reported for the combined numbers of both groups. Group 1 includes children from 3 years through 3 years 3 months; group 2, 3 years 4 months through 3 years 7 months; group 3, 3 years 8 months through 3 years 11 months; group 4, 4 years through 4 years 3 months; group 5, 4 years 4 months through 4 years 7 months. Figures in brackets represent correct response to the quantity of the array ("same" or "different") prior to the addition, and the quantity after the addition or subtraction. The figures in this category without brackets are for the correct response to the addition or subtraction operation alone. The arrangements (A–H) are shown in Fig. 1.

Trials	Group				
	1	2	3	4	5
A	14	15	19	15	9
B	33	44	41	35	30
C	24	33	30	29	38
D	33	47	37	47	47
E	17	63	52	59	67
F	67	81	65	88	87
G	47	65	67	77	82
	[18]	[40]	[42]	[61]	[68]
H	65	73	78	83	91
	[26]	[46]	[51]	[61]	[74]

of both equality and inequality is very low for all age groups as represented by the average percentage of correct responses in these trials. Since the probability of chance success by guessing in any static conservation trial is 50 percent and in any transformation trial is 25 percent, response is close to or below chance in all conservation conditions. Not a single child at any age tested was correct in all three conservation-of-equality trials, and only 7 percent in the oldest age group were correct in conservation-of-inequality trials. With a criterion of two out of three correct, the level of correct performance increases, but to no higher than 20 percent in any age group; there is no age trend.

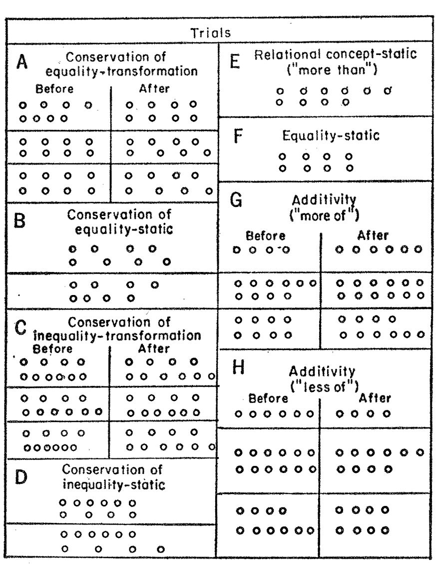

Fig. 1. Stimulus arrays for static and transformation trials in conservation, relational, and additive conditions.

By contrast, even the youngest children in the sample exhibit a high level of correct performance in the "equality" test, where number and extension of static arrays are equal. This is likewise true where the relational judgment ("more than") is made (*5*).

Although correct responses with respect to conservation of equality and inequality are greater in the static than in the transformation condition, both are at about chance level. This differs from data reported previously (*4, 6*) for equality-of-area judgments in children from kindergarten through fourth grade. Static conservation was consistently more difficult for those children to achieve than transformational conservation. This difference in performance suggests that younger children are unable to correctly utilize the information imparted by the transformation; that is, transformation leads to the incorrect "perceptual" inference that the longer or shorter row is different in number from the standard when it is in fact equal. Older children are more able to use the transformation information because of the possession of an inference-generating mechanism. Younger children apparently lack such a mechanism or, if they have it, are unable to use it; thus performance in both static and transformation conditions is determined by chance factors.

The additivity concepts ("more of" and "less of") are the only ones in the present instance which show an age trend (positive). An appreciable percentage of even the youngest age group respond correctly (*7*).

Young children, then, within the age range of 3 years to 4 years 7 months display very little, if any, conservation ability. They do have some conceptual capacities ultimately necessary for conservation, but they lack the inference-generating mechanism that makes possible a judgment of equality or inequality in the face of spatial transformation or dislocation. The high level of response of Mehler and Bever's subjects is most likely due to the combination of addition and relocation tasks in the experimental operations. The decline and rise in performance also reported by Mehler and Bever is not confirmed.

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References and Notes

1. J. Mehler and T. G. Bever, *Science* **158**, 141 (1967).
2. J. Piaget, *The Child's Conception of Number* (Routledge and Kegan Paul, London, 1952).
3. H. Beilin, *J. Exp. Child Psychol.* **1**, 208 (1964).
4. ———, *ibid.* **3**, 267 (1966).
5. This result is something of an anomaly since previously I found that in area judgments equality is more difficult to judge than inequality. The difference between the past and present results may be either a function of age (since the present subjects are younger than the kindergarten children of the prior study) or of the different quantitative concepts employed (that is, area as opposed to number) in that the defining characteristics of "same number" are better known to young children than the defining properties of "same area."
6. H. Beilin, in *Studies in Cognitive Development: Essays in Honor of Jean Piaget*, D. Elkind and J. H. Flavell, Eds. (Oxford Univ. Press, New York, in press).
7. The number of responses is somewhat less when the additivity response is contingent upon a correct prior response.
8. Supported in part by PHS research grant HD 00925-07 from the National Institute of Child Health and Human Development. I thank George E. Spontak and Sandra J. Dalton for assistance.

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What Children Do in Spite of What They Know

Abstract. *New studies support the hypothesis that young children have basic cognitive capacities but utilize them inefficiently; older children aid these capacities with generally valid cognitive heuristics which produce poor performance on critical problems.*

In a previous study of cognitive development we found that children of 2 years 6 months can successfully recognize a numerical equality and its transformation into an inequality whereas older children temporarily lose this capacity. We interpreted our results as demonstrating that the capacity to conserve relations between stimuli in the face of transformations is present in the 2-year-old; the older child loses this capacity temporarily due to an overdependence on perceptual generalizations (for example, "if a row looks longer, it has more components in it"). This interpretation conflicts with the position that the ability to conserve numerical relations between stimuli first appears at about 5 to 6 years (*1*).

Beilin's critique of our previous study contains three general points: (i) our study was not a direct test of the child's capacity to conserve; (ii) his experimental evidence indicates that children up to 4 years 8 months do not understand the word "more" as a static relational term but as meaning "more than it had before"; and (iii) his conservation experiments do not find any developmental trend during the 3rd and 4th year.

There can be no conflict regarding the facts of the child's behavior since Beilin did not attempt to replicate our study; he neither studied children under age 3 nor did he present any of his subjects with the experimental problem that we had used. However, since many other psychologists have indicated similar objections to our research, we shall concentrate primarily on the relevant theoretical aspects of Beilin's paper.

When a child discovers a particular set of dimensions that stimuli can have, he must then learn to interrelate those dimensions. For example, the capacity to recognize a property like the length of a row or the number of objects in it does not itself aid the child in making correct judgments about relations between rows. He must first discover general principles for the simultaneous combination and transformation of such properties. Piaget (*2*) has suggested that the set of principles required to deal simultaneously with dimensions of a particular class are logically described as a group structure; each group specifies an interrelated set of operations for the combination and transformation of dimensions. The simultaneous presence of all group operations is necessary for the child's cognition to be in a state of equilibrium with respect to those dimensions of his experience.

Piaget interprets the ability to conserve relations between stimuli in the face of superficial transformations as a behavioral sign of the presence of such an equilibrium in the child's thought. For example, if the two stimuli (Table 1) in (1a) are transformed to appear as in (1b), the child can realize that the numerical relation between S1 and S2 is the same in (1b) as in (1a) only if he knows (at least intuitively) that the shape transformation does not involve a change in number from the original relation. Similarly, in (1c) and (1d) a child knows that the numerical relation between S3 and S4 is changed only if he can appreciate the fact that the number transformation between (1c) and (1d) involves addition to one of the rows. Thus, cognitive mastery of the different dimensions of objects requires knowledge of which transformations change a relation and which transformations conserve a relation.

Table 1. Transformation tasks administered.

Sequence	Initial set	Transformed set
	Shape transformation	
S1	0 0 0 0	0000
S2	0 0 0 0	0 0 0 0
	(a) ⟶	(b)
	Number transformation	
S3	0 0 0 0	0 0 0 0 0 0
S4	0 0 0 0	0 0 0 0
	(c) ⟶	(d)
	Number and shape transformation	
S5	0 0 0 0	000000
S6	0 0 0 0	0 0 0 0
	(e) ⟶	(f)

If these considerations are correct, they place several requirements on any experimental demonstration of the presence of the capacity for conservation. First, there must be a set of stimuli which bear an initial relation to each other that the child is capable of understanding. Second, there must be at least one transformation applied to the initial set which changes one dimension of the stimulus. Third, the relation between the stimuli in the transformed set should not be obvious to the child independent of the initial relation [that is, the child must use the relational information presented in the initial set or in the transformation (or in both) to solve the final problem]. Fourth, the child must have an unambiguous way of spontaneously indicating that he understands the transformed relation.

Table 2. Responses to (b) on equality conservation sequence (1a)–(1b) of Table 1 (*3*). Different subjects were used in paradigms A, B, and C. In paradigm A subjects saw the transformation; in B subjects did not see the transformation; in C subjects were forced to indicate one row as having "more" (did not see the transformation).

Age (year and month)	Children (No.)	Percentage response, saying: Same number	S1 has more	S2 has more
		Paradigm A		
2/0–2/11	10	80	10	10
3/0–3/11	16	50	13	38
4/0–4/11	11	64	9	27
		Paradigm B		
2/0–2/11	37	48	3	49
3/0–3/11	34	35	18	47
4/0–4/11	35	29	0	71
		Paradigm C		
2/0–2/11	20		40	60
3/0–3/11	8		0	100

The sequence (1a)–(1b) fulfills all these conditions for use with older children. They characteristically indicate that there is the same number of objects in each row in set (1b) because there is nothing done in the transformation from set (1a) to change the actual quantity of S1. A surprisingly large number of young children (Table 2A) maintain that the two rows in (1b) have the "same" number of clay balls in them. We felt that the young children might mean that the two rows in (1b) are still individually the same rows as they were in (1a); that is, that identity of the rows was preserved by the young child even though the relation between the rows may not have been conserved. Support for this interpretation is given by the fact that the young children perform less well if they do not observe the transformation from (1a) to (1b) [although they still perform better than older children (Table 2B)]. Thus, for the 2-year-old, the sequence (1a)–(1b) may not meet the fourth requirement on an experimental demonstration of conservation (*3*).

Similarly, a study in which the transformation from (1c) to (1d) was used indicates that the young child performs extremely well (Table 3). However, this too might have been the result of the child's ability to judge the relation in condition (1d) independently of the antecedent condition (1c); that is, in (1d) the relative density of S1 might be an independent perceptual cue for the young child. Thus, the sequence (1c)–(1d) does not meet the third condition above (*4*).

Therefore, to overcome the experimental problems of working with children 2 years old, we combined the shape and number transformations and examined the child's reaction to the transformation of (1e) and (1f) (Table 1). With set (1f) the child was asked which row had "more" balls in it. Although S5 is more dense than S6, it is also shorter; thus it is possible to argue that the third condition is met: there is no obvious perceptual basis for a correct decision in (1f) independent of (1e) and the transformations. Thus, the young child's ability to perform correctly on this problem is a sign of the capacity to conserve. However, we agree that this experimental paradigm is more complex than the usual test of conservation; it was necessary in order to accommodate to the experimental difficulties associated with interviewing 2-year-old children (*5*).

We felt confident that the young child does understand the word "more" as a relational term (so that the fourth condition was met), even though he may not always understand "same" as a quantitative relational term. It is this belief that Beilin questions most strongly. His hypothesis is that our young subjects systematically misunderstood the question about (1f) and were answering that S1 had had "more added" to it, not that it had "more than" S2.

First, linguistic differences are not explanations of cognitive differences but reflections of them (*2*). Second, although it might be true that the young child was using the additive interpretation of "more," there are several empirical considerations which invalidate this possibility. Beilin's data indicate that children do not start to understand the additivity interpretation of the word "more" until age 3 years 4 months. Yet children younger than this respond correctly to condition (1f) whereas the performance of older children is dramatically worse. In addition, we interviewed children from 2 years to 5 years on the same problem as in (1e)–(1f) but these children did not observe us transforming (1e) into (1f). [The stimuli used in (1e) and (1f) were glued on prepared boards and presented in sequence.] Thus the subjects did not observe the activity of our adding more to S5 nor did they observe us compressing it. Despite the lack of additivity cues (or cues which might call attention to S5 as the manipulated row), the results confirm our earlier findings (Table 4).

Beilin scores a child as correct in all his tasks only if the child responds correctly on both the initial and the transformed set of stimuli. According to his own results on static judgments, under 65 percent of children correctly understood the initial relation in the equality paradigm and under 35 percent in the inequality paradigm. Thus, in Beilin's conservation paradigms, less than 50 percent of the children met even the first condition. If most of the children did not understand the relation, how can one assess their failure (or success) at conserving it?

Table 3. Responses to (d) on sequence (1c)–(1d) of Table 1. Subjects did not observe the transformation.

Age (year and month)	Children (No.)	Percentage response, saying:		
		Same number	S3 has more	S4 has more
2/0–2/11	13	0	69	31
3/0–3/11	8	50	38	13
4/0–4/11	8	13	88	0

Table 4. Performance on (f) in sequence (1e)–(1f) of Table 1. Subjects did not observe the transformation.

Age	Children (No.)	Percentage correct
2/0–2/5	14	93
2/6–2/11	19	37
3/0–3/5	28	38
3/6–3/11	30	57
4/0–4/11	50	50

In Beilin's static conservation tests of inequality (in which the child is asked to judge the numerical relation between two rows), children perform extremely poorly. This indicates that the child does not understand the relational term "more" even at age 4 years 4 months to 4 years 7 months. If this were true, how could Beilin (or Piaget) maintain that the child at that age is nonconserving of the equality (or inequality) relations presented in the initial set since he does not understand the question? If Beilin were correct in the view that the child has not even started to interpret "more" as a relational term at age 4 years 7 months, it would be as much a problem for him and Piaget as for us.

There are several specific methodological techniques which may contribute to the extraordinarily low performance of Beilin's subjects at all ages [even on such simple tasks as the equality of the rows in (1a) or the inequality in (1d)]. First, he asked children to make judgments on behalf of dolls; we found that asking children to make judgments on behalf of dolls as opposed to their own behalf often increases fluctuations in the responses (*6*). [However, the same decrease in performance with age is observed in the children who made consistent judgments on which doll has "more" in (1f).] Second, Beilin used a fixed order of experimental paradigms across all children; we have found that the effects of experimental order are large; younger children quickly tire of such experiments (*7*). Finally, we are startled that Beilin did not use Piaget's methodology, which is characteristically adaptable to each particular subject. In particular, the importance of Beilin's data (as well as the true performance of his subjects) would have been significantly enhanced if he had encouraged each child to understand the initial relation of each set, before testing the child's ability to conserve that relation under transformation.

Many structures and functional capacities are present in the cognition of the 2-year-old child. However, his ability to express these capacities is limited because memory and attention span are not well developed. As the child accumulates experience, he develops cognitive heuristics which help him to overcome these basic behavioral limits. Although these cognitive heuristics are generally valid, they fail in critical instances, and eventually the child either rejects the heuristics or learns to use them only when they apply.

We agree with Beilin that these theoretical claims are extremely strong and that a broad base of empirical support is necessary before they are accepted. In particular, our claim that the child of 3 performs less well on cognitive problems, owing to an overdependence on perceptual generalizations, must be explored with tasks other than judging the relative number of small rows of clay balls. We have studied similar decreases in performance with age in the long-term memory of figures, volume inequality, sentence comprehension, discrimination-learning, and other tasks (*8*).

Even more crucial is our hypothesis that the basic cognitive structures are available to the 2-year-old, but that he cannot utilize them efficiently. We certainly agree with the balance of nativism and empiricism in (Beilin's interpretation of) Piaget's view that: "(cognitive) competencies reflect the influence of maturational and experiential determinants under the control of an internal self-regulating mechanism." It remains an empirical question, however, which component functions of human cognitive abilities are relatively autonomous, which emerge with experience as a catalytic agent, and which are learned primarily from experience (*9*).

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References and Notes

1. J. Mehler and T. Bever, *Science* **158**, 141 (1967).
2. J. Piaget, *The Heinz Werner Lectures* (Clark Univ. Press, Worcester, Mass., 1968); *The Psychology of Intelligence* (Routledge and Kegan Paul, London, 1950).
3. In Table 2, A and B, and Table 3 half the children in each age group were asked: "Do the rows have the same number of balls in them or does one row have more balls in it?" The other children were asked: "Does one of the rows have more balls in it or do the rows have the same number of balls in them?" The questions were force-choiced between "same" or "one row has more," because our work showed that young children tend to say "yes" or "no" to every simple yes/no question. There was an effect of question order: children tended to respond with the last adjective ("same" or "more") in the question. However, this effect was stronger for older children and does not account for the high performance of the young children. As in our previous experiment, the orientation of the sets of stimuli were randomized for each age group in all the experiments reported. All children were pretrained on the concept of a row with five small stuffed animals arranged in a line, as an example.
4. Table 2C indicates that there is no tendency in the 2-year-old child to choose the more dense row as having "more" when the rows are numerically equal, as in (1b). The 3-year-old incorrectly judges the two rows in (1d) as the "same" number much more than the 2-year-old. This is additional evidence that the 3-year-old uses length as the basis for numerical judgments, whereas the 2-year-old does not.
5. We had felt that the basis of our use of the term "conservation" in the absence of a classical test of conservation was clear in our previous paper. We apologize to any reader who was misled by our confusion.
6. We found that asking the young child if it would be "fair" if one doll had S1 in (1b) and another doll had S2 was not satisfactory, since the young children seemed to think that anything was "fair" so long as each doll had at least some balls to play with.
7. In our studies, children below age 4 have some tendency to change their answers when asked the same kind of question more than once; we think that this results from the child's assumption that being asked a second time indicates that his first answer was incorrect. Some of the children in our first study were also asked to choose on behalf of dolls which row in (1f) has "more." Of the children from 2 years to 4 years 6 months who performed on all tasks (observing the transformation), 79 percent took the row of M & M's with more, 62 percent correctly indicated the row with "more," only 39 percent correctly indicated which of two dolls had the row with "more." We interpret this as showing that the more engaged the child is with a perceptual judgment the less likely he is to rely on superficial perceptual generalizations. Making judgments on behalf of dolls does not engage the child's capacity as fully as making a judgment on his own behalf or taking a row of M & M candies to eat.
8. J. Mehler, *Int. J. Psychol.*, in press; T. Bever, J. Mehler, V. Valian, in *The Structure and Psychology of Language*, T. Bever and W. Weksel, Eds. (Holt, Rinehart, and Winston, New York, in press); J. Mehler and T. Bever, *Int. J. Psychol.*, in press; T. Bever, in *Cognition and Language Development*, J. Hayes, Ed. (Prentice-Hall, New York, in press).
9. In response to Beilin's reply to this paper: (i) The (1e) to (1f) transformation is a test of the "capacity" to conserve, not merely a "control condition." (ii) The young child does not have a general strategy of choosing the denser row as having "more" (see footnote *4*) and Table 2C). (iii) Failures to replicate our findings on the (1a) to (1b) transformation (Table 2, A and B) must be examined for similarity of technique and scoring. (iv) We are indebted to Beilin for pointing out a gap in this report: less than 5 percent of our subjects failed to agree on the initial equality of (1a), (1c), or (1e) (after discussion in some cases), and most of those were over 3 years old. Therefore our data were not significantly "inflated by including children who are incorrect in their initial judgments and correct in the transformation response," while Beilin's data appear to be significantly "deflated" by including such children as "nonconservers." This remains the heart of our critique of Beilin's data analysis: if a child does not understand the initial relation (whether spontaneously or after discussion), how can he be expected to "conserve" that relation under transformation?
10. Supported by Army Research Projects Agency grant SD-187 to Harvard University and Foundation Fund for Research in Psychiatry G67-380. Research was carried out with children whose mothers volunteered their time to us. We are particularly grateful to Jonas Langer and Harry Beilin for stimulating much of the research reported, and to Peter Carey for advice on this manuscript.

22 August 1968

In Bever, Mehler, and Epstein's defense of the earlier study by Mehler and Bever (*1*), the (1e) to (1f) transformation is no longer used as a test of conservation but at best as a control condition related to such a test. As an attempt to show that a judgment of inequality in the face of contradictory cues must be based upon (still unidentified) nonperceptual processes, it is questionable whether the (1e) to (1f) transformation even meets the requirements of their third condition, since it is possible that the closely packed aggregates of objects may be judged as "more" on perceptual bases alone.

The finding by Bever *et al.* that 60 percent of their sample of 2-year-olds in the forced-choice 2C condition chose the spread-out array as "more" creates a problem in the interpretation of the data of (1f). If 93 percent of the 2-year-olds judge the dense display in (1f) as "more," such a choice must be based on either cognitive or perceptual grounds. Solution in cognitive terms is possible by counting or by using a method of one-to-one correspondence, neither of which is claimed by Bever *et al.* Otherwise, the child is responding to the perceptual arrangements—either the compression of one array, the spread of the other, or the contrast of the two arrays.

Irrespective of the interpretation given to the results of the (1e) to (1f) transformation in this and the earlier study, in the classic conservation case [the (1a) to (1b) transformation] Bever *et al.* obtain results which have not been independently validated in my own and three other studies which cover the entire age range under discussion (*2*). Furthermore, it is difficult to understand the criticism by Bever *et al.* of recording a child's transformation response as correct and relevant only in conjunction with an initially correct equality or inequality judgment, when their third condition requires that "the child use the relational information presented in the initial set and/or the transformation." This also means that the data of Bever *et al.* are inflated by the inclusion of children who are incorrect in their initial judgments and correct in the transformation response. There is no problem, as they imply, created by my initial response data. Between 67 and 87 percent of the subjects were correct in static equality judgments; similarly, the children performed well with additive inequalities, although less well with static relational judgments. The essential point is that very young children have a fairly adequate concept of equality and yet, in spite of this, they fail to conserve that relation. If the child fails to understand the initial relation, however, it is indeterminable whether he can conserve; all such subjects (even 5 percent) would have to be so identified.

My data do not confirm the conservation findings of Bever *et al.*, nor their report of the more basic equality and inequality concepts. I concur in the belief that the differences are probably the result of differences in the test procedure. I find it strange, however, to have to account for using an "experimental" rather than a less specifiable "clinical" method.

While I question the methodological and conceptual bases for the conclusions of Bever *et al.*, I nevertheless feel that they have done a service in exploring one aspect of the little-known cognitive capacities of children between the ages of 2 and 5.

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References

1. J. Mehler and T. G. Bever, *Science* **158**, 141 (1967).
2. L. S. Siegel and A. G. Goldstein, unpublished report (copies available from L. S. Siegel, McMaster University, Hamilton, Ontario, Canada); B. B. Rothenberg and R. G. Courtney (Educational Testing Service, Princeton, New Jersey, in press); J. Piaget, *Science*, in press.

23 September 1968

Heritable Repression due to Paramutation in Maize

In the penetrating analysis and interpretation of paramutation at the *R* locus in maize by Brink, Styles, and Axtell (*1*), information that I have presented on the phenomenon at the *B* locus is briefly considered. Although the *B* data clearly show that paramutation in this system and others might well be interpreted as a meiotic and terminal phenomenon, the interpretation of Brink, Styles, and Axtell is that all paramutation is somatic (or, rather, premeiotic), and that the data for *B* do not raise doubt on this point. Related comments are needed also on their conclusion that paramutation at the *R* locus cannot involve transfer of particles between alleles. Only when these mechanical features of paramutation are defined will it become clear whether paramutation systems involve typical or unique mechanisms of gene regulation, and whether the biological significance of paramutation is ontogenetic or phylogenetic.

Paramutation at the *B* locus occurs late in ontogeny. This conclusion rests on clear evidence, partly phenotypic and partly developmental (*2*). Examples cited by Brink, Styles, and Axtell from several plant species in support of an opposite conclusion all depend on the conventional view that somatic sectoring demonstrates the occurrence of paramutation *in the mitosis* at which the sector was delimited. As discussed elsewhere (*2*), differential mitoses that result in sectors may be differential in the potential for paramutation, rather than in the paramutation event itself. Similar delayed timing in repression-control systems has been found by McClintock (*3*) in the "presetting" phenomenon, in which a gene is programed at one stage of development to function subsequently in patterned concert, even as late as in the next generation. The *B* data show that all or most of a life cycle can intervene between the formation of the paramutational heterozygote and the paramutation event. Consequently, the question of whether paramutation can be generalized as premeiotic (or as meiotic-terminal) is entirely open. Definitive experiments identifying the exact stages of the events have not yet been devised.

The mechanics of paramutation at the *R* locus are discussed by Brink, Styles, and Axtell (*1*). Their data show that increase in functional capacity of *R*, which, they hypothesize, reflects loss of repressor elements, occurs in *Rr* heterozygotes. Since the same change occurs in deficiency heterozygotes (*R*—), loss of repressors, they point out, cannot be occurring by transfer to the absent homologous region. Brink, Styles, and Axtell argue that transfer is thereby excluded as a mechanical process for all *R* paramutation. However, the changes that can be interpreted as due to *gain* of repressors occur only in the presence of R^{st} or alleles with more repressors. Whether paramutation is meiotic or premeiotic, through contact or otherwise, a mechanical process by which gain occurs must be considered, and gain of elements by transfer is a conceptually economical hypothesis for the mechanics of change of *R* to *R′*. According to this view, loss of elements could be permitted by the *Rr* or *R*— condition, since no supply of elements would be provided by the allele. The data do not warrant disposal of the transfer model.

The late timing of paramutation at the *B* locus and the interpretation of particle transfer have led to the suggestion (*2*) that release of a repressor element (from *B′*) is triggered at or near meiosis, and that the element then transfers to the allele (*B*). The mechanical process in terminal pigmenting cells can be viewed as parallel to that in germinal cells but as less efficient, perhaps due to the absence of synapsis. A model of the kind suggested below, even though unduly exact, may express this repressor-transfer view less abstractly. Stent (*4*) has suggested that appended messenger RNA may act as a repressor, and more recently Bonner and Widholm (*5*) have presented evidence for chromosomal RNA that is organ-specific and complementary to nuclear DNA; this chromosomal RNA may be an integral part of gene repression systems. In parallel with repression by end-product feedback in bacteria (*6*), repressor (RNA or otherwise) released from a heritably repressed gene (*B′*, *R′*, R^{st}) could transfer as feedback to the allele (*B*, *R*) and append to the DNA. Since the genetic software (the repressing material) must be able to replicate along with the gene it represses, one would suppose that appended RNA might be capable of replication in place. Transfer of such a repressor, either by contact or by release and migration, would be entirely reasonable and not incompatible with either the *R* or the *B* information.

Exact materials and mechanics for paramutation can be hypothesized, and there will be differences of opinion about the hypotheses. There is full agreement, however, on this important fact: potential for genetic activity can be altered by the history of a gene, and associated software appears to be responsible in both of the cases that have been thoroughly studied.

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References and Notes

1. R. A. Brink, E. D. Styles, J. D. Axtell, *Science* **159**, 161 (1968).
2. E. H. Coe, Jr., *Genetics* **53**, 1035 (1966).
3. B. McClintock, *Develop. Biol. Suppl.* **1**, 84 (1968).
4. G. S. Stent, *Science* **144**, 816 (1964).
5. J. Bonner and J. Widholm, *Proc. Nat. Acad. Sci. U.S.* **57**, 1379 (1967).
6. E. McFall and W. K. Maas, in *Molecular Genetics*, J. H. Taylor, Ed. (Academic Press, New York, 1968), pt. 2, p. 255.

7. This comment is a contribution from the Agricultural Research Service, U.S. Department of Agriculture and the Missouri Agricultural Experiment Station (Journal Series No. 5370).

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Oceanic Basalt Leads and the Age of the Earth

In a recent report Ulrych (*1*) claims to have derived an "independent age for the earth." He states that the significance of his calculations is that the "age" which he obtains for the earth is independent of the age of the samples used in the calculations. It is true that his method does not require an independent determination of the length of time that a related series of rocks have spent in the crust, as long as their original source was homogeneous from T_0 (the time at which the gross structure of the earth developed) until the time at which the rocks were derived from the source, T_1 (the age of the samples). However, the absence of an independent criterion for determining that this condition is met introduces several problems.