Vitamin K–Induced Prothrombin Formation: Correction

I am indebted to M. J. Smith of the Massachusetts General Hospital for pointing out to me that plasma thromboplastin antecedent (factor XI) is not a vitamin K–dependent clotting protein. In a recent paper [*Science* **145**, 926 (1964)], I had listed it along with plasma thromboplastin component (factor IX), proconvertin (factor VII), and prothrombin as clotting proteins under probable genetic control by vitamin K in the mammal. Instead of PTA, I should have listed Stuart's factor (X), which appears now to be well established as a vitamin K–dependent clotting factor.

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Study of Creative Scientists: Comments on Methodology

Some methodological restrictions on inferences from apparently straightforward data on religion and scientific attainment may not be generally known; preliminary findings in this area previously have been widely and uncritically cited, gathering authority beyond that justified by the nature of the samples and the experimental design. It may therefore be appropriate to consider some limitations on Chambers's conclusion (*1*) that "religious preference is much more strongly associated with choice of science as a career than it is with achievement of highly creative productivity within a specific discipline."

1) An association between religion and choice of science as a career is not demonstrated merely by describing the religious background and current religious preferences of a sample of scientists. At least one problem may be considered. Most scientists are highly educated; the religious preferences of highly educated individuals (98 percent of Chambers's sample were Ph.D.'s) may, for a variety of reasons only indirectly associated with religion, be different from those of a more general population, without any necessary differentiation between scientists and nonscientists. While there are no adequate comparison data, it may be noted that Ament (*2*) has tabulated affiliations listed in *Who's Who* for scientists and men distinguished in other fields. The proportions of Protestants, Catholics, Jews, "others," and "no preferences" (to use Chambers's categories) were not significantly different for scientists and men of arts and letters, although both groups differed markedly from the general population.

2) The same comments apply to the other evidence cited by Chambers (college attended and parental religion). Interpretation of the finding that 1½ percent of all scientists attended Catholic colleges is additionally obscure, since the implicit assumption that only Catholics attend Catholic colleges and no Catholics attend other institutions is patently untenable.

3) Even if Chambers had unequivocally demonstrated a distribution of current preferences unique to scientists, the issue of cause and effect would still remain. The "relation" may be primarily between values developed during a career in science rather than values involved in choosing science as a career. Certainly among individuals currently at the threshold of their careers, there seems to be little relation between religious background and interest in science; Greeley (*3*) has found that the proportions of college seniors planning careers in science, in the social sciences and the humanities, and in engineering were not significantly different for those raised in Jewish, in Catholic, and in Protestant faiths; 8 percent of the students of Jewish origin, 6 percent of those of Catholic origin, and 7 percent of those of Protestant origin intended to become scientists. The distribution of religious preference at a median age of 53 would seem only tenuously related to the differential choice of science as a career three decades earlier.

4) Chambers's conclusion is based on data from a rigorously selected sample of scientists: eminent psychologists and chemists, and controls individually matched for age, discipline, education, sex, and opportunity to do research. As an example of how this may affect conclusions about religious background and choice of career: The median age of the scientists in the sample is 53 years. The median age of the 215,000 persons listed as scientists in the National Register of Scientific Personnel is 38 years, and the median age of the 66,000 registered Ph.D.'s is 41 years (*4*). While, again, there are no adequate comparison data, it should be noted that Clark (*5*) reports a significant difference in the distribution of parental religious affiliation for psychologists who received the Ph.D. in 1930–34 and those who received it in 1940–44; he notes that responses from the 1950 Ph.D.'s show the trend has continued. The other ways in which Chambers's sample may differ from the broader class of scientists could also restrict generalizations about choice of career, creativity, and affiliation to the smaller class of scientists with similar characteristics.

5) This point concerns inferences which can reasonably be drawn from the questionnaire response of a minority of subjects. Approximately 60 percent (438 out of 740) of the originally selected scientists returned the questionnaire. Of the 60 percent, 40 percent (43 out of 110) of the creative psychologists and 16 percent (17 out of 108) of the creative chemists did not indicate any current preference (*6*). The conclusion that creativity and current preference are relatively unrelated is thus based on 39 percent (67 out of 170) of the original sample of creative psychologists and 45.5 percent (91 out of 200) of the original sample of creative chemists. With so small a proportion of known preferences, any statement about Chambers's *sample* is questionable, let alone generalizations about the population of scientists to which the conclusion is directed.

6) In view of the frequency with which certain denominations have been reported to be "overrepresented" and others "underrepresented" among scientists, a cautionary note should be sounded about drawing inferences from essentially descriptive data. Information on family religious background, religious preference during the period of career choice, and current religious affiliation is clearly needed for eminent and noneminent scientists and eminent and noneminent scholars in other disciplines before the nature of the relations among religion, science, and creativity can be meaningfully discussed.

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2. W. S. Ament, *School and Society* **26**, 399 (1927).
3. A. M. Greeley, *Am. J. Sociol.* **68**, 658 (1963).
4. "American Science Manpower, 1962," *Natl. Sci. Found. Publ. 64-16* (Government Printing Office, Washington, D.C., 1964).
5. K. E. Clark, *America's Psychologists* (American Psychological Association, Washington, D.C., 1957).
6. J. A. Chambers, personal communication.

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As one who has done research on creativity (*1*), I am well aware of the difficulty of establishing criteria for this trait. Some arbitrary standards must be chosen, and they will not satisfy everyone. But it seems to me clear that Chambers's criteria are indicative not of creativity per se but of quantity of production.

Chambers claims that number of publications did not serve as a criterion for admission to his highly creative group, and he finds that his creative scientists published and presented more papers than did his controls. His creative scientists were chosen "on the basis of having achieved eminence as research scientists, as recognized by membership in the National Academy of Sciences or the American Philosophical Society, being starred in *American Men of Science*, or similar evidence. . . ." A rudimentary knowledge of the contemporary scientific world indicates that publications and papers are factors in achieving eminence. His selection was therefore biased in favor of scientists who are highly productive of publications and papers. Further, the fact that people who have been rewarded for research accomplishments produce more research can be explained without reference to creativity.

I should like to see a study in which quantity of production is held constant, and then differentiation is made between highly creative and less creative scientists. As Bixenstine (*2*) and numerous others have complained, we have a great quantity of contemporary research, but the quality often leaves something to be desired.

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In answer to Datta, I should first point out that the study of creativity was concerned primarily with differences between creative and noncreative scientists, not with differences between scientists and other persons. Perhaps religious preference as found in my study may characterize not scientists but rather highly educated people as a whole. The Ament study, however, offers little evidence pro or con, since it is concerned only with eminent persons in the various categories and makes no comparisons with noneminent persons.

In all four of the groups in my study, the proportions reared in Catholic homes or giving their current religious preference as Catholic were appreciably smaller than would be expected on the basis of population ratios (Tables 1 and 2). These data, based on items in the questionnaire, support the points of view expressed in my report. Greeley's study, although having the advantage of using subjects at the age of career choice, has the disadvantage of depending upon stated intention rather than achievement. Since for many reasons such intentions may not be carried out, the evidence from studies of this nature (using college students as subjects) does not seem as meaningful as do the results of studies comparing persons who have actually achieved the chosen career.

A longitudinal study might show changes in the relations between religious background and choice of career; however, unless those changes affect creative and noncreative persons differently, they would not erase the differences between creative and noncreative scientists. I agree with Datta that a great deal more study is needed before any final conclusions may be drawn; the basic difficulty is that few comparative data are likely to be available, because of the increasing avoidance of questions about religion on forms accumulated on highly educated people which would normally serve as data for researchers.

In regard to Eisenman's comments: much of the information about sample selection and the like was omitted from the report in *Science* for the sake of brevity. In order to avoid selection of persons on the basis of productivity and to select for the creative groups only persons who had achieved eminence on the basis of the *quality* of their research, in addition to the selection procedures listed in the report in *Science* several other methods were employed. First, I read the available biographical information on all the subjects in *Who's Who in America, American Men of Science*, and similar publications, and attempted to include only those persons who had achieved recognition for creative research. The lists of creative and noncreative scientists were then submitted to committees comprised of three mature scientists in each discipline. These persons were asked to eliminate the names of those persons who, in their opinion, did not qualify to serve as members of the group for which they had been chosen. This step was taken to eliminate persons who still remained on the creative lists predominantly on the basis of productivity rather than creativity; and in this step a number of persons were eliminated from each group. As may be seen in Table 3, although on the average the creative scientists have published a great many more articles than the controls, some creative scientists have achieved eminence on the basis of—in psychology—as few as five published articles and—in chemistry—as few as three books with no articles. There were quite a number of subjects in the creative groups, in fact, who had very low productivity but still had managed to achieve a great deal of recognition for the quality of their work.

Table 1. Religious leanings in childhood homes of subjects (EP, creative psychologists; CP, control psychologists; EC, creative chemists; CC, control chemists).

Religion	EP	CP	EC	CC
Protestant	77	79	84	99
Jewish	21	12	12	3
Catholic	5	8	5	8
Other	1	1	1	1
None	6	2	6	5

Table 2. Religious preferences of subjects.

Religion	EP	CP	EC	CC
Protestant	48	64	73	89
Jewish	10	7	9	3
Catholic	1	6	4	9
Other	8	7	4	5
No preference	43	17	18	11

Table 3. Number of published articles.

EP	CP	EC	CC
	Range		
5–300	0–70	0*–700	0–230
	Median number		
42	10	78	17

* This man published his findings in three books.

Interested readers may refer to the entire study, "Relating Personality and Biographical Factors to Scientific Creativity," *Psychological Monograph No. 584* (1964).

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