dents in related fields, and at the same time offering to the large mass of students without such professional objectives an opportunity to get at least a bird's-eye view of the field under competent tutelage. In many instances existing courses for non-technical students can be altered, combined or rearranged to meet the existing need. If some such solution is not found we shall have no right to complain when the American people derive their notions about evolution from William Jennings Bryan, about animal experimentation from Irene Castle or William Randolph Hearst and about medicine from B. J. Palmer or Mary Baker Eddy.

A university must and does serve many functions. It seems that it is not too much to ask that it carry out its job of giving its graduates as least a speaking acquaintance with the scope of science. The vexatious problem of the vested interests of specialty groups, anxious to avoid loss of prestige and financial support through a decrease in numbers of students in existing courses, should not be allowed to stand in the way of achievement of a goal, larger by far for both science and society than the disarrangements it will require for its achievement.

As a specialist in a branch of biology directly involved in the program under discussion, I am anxious to see the most important facts and principles of that branch be known and appreciated by as large a fraction of the public of which we are a dependent part, as is reasonably possible. I am convinced, first, that there will be no loss in prestige or economic support for that science as a consequence, and second, that such education will improve and enrich the lives of the generation acquiring it. It seems very likely that the whole realm of basic sciences would receive the greatest impetus possible if the people at large had even the barest sort of conception of how applied science rests upon progress in pure science. Many scientists to-day complain bitterly about the partiality of the public in the support of applied as opposed to pure science. There is little to be wondered at in such discrimination, since any one who can read knows something about the achievements of applied science. If we in the basic sciences are unwilling to play our part in mass education in the essentials of the pure sciences we shall have no one to thank but ourselves for the discrepancy in support that will result.

A corollary of the argument I have made is that professional students of science need a great deal more acquaintance with the literary, artistic and social heritage of the human race than they now acquire. The general cultural education problem has many facets, and although I have stressed only one because it is in my province as a teacher, I can not refrain from inserting the suggestion that the general education of scientists, pure and applied, deserves a much greater emphasis upon cultural phenomena than it has received in the recent past, and that comparably comprehensive presentations in these areas will assist greatly in meeting this need.

A move in the direction of less fragmentation into small subdivisions in the teaching of science to students without professional objectives in the areas in question seems to offer the best hope we have for the restoration of opportunity to college students to acquire a liberal education in the best sense. It presents an opportunity to make many more citizens intelligently aware of the importance of basic science to applied science and human welfare. It need not detract an iota from the thoroughness of training of specialists in science, nor decrease the prestige or financial support of basic science departments. In fact, it seems that to extend support for work in the basic sciences, greater public appreciation of their important role in human welfare is much needed.

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GREGOR MENDEL'S EXPERIMENT ON THE NATURE OF FERTILIZATION

IN "The Evolution of Genetic Systems," C. D. Darlington reviews "the three vital experiments" on which modern genetic principles are founded: 1—the proof by Johannsen that the genotype is independent of the environment; 2—the proof by Gregor Mendel that the genotype is composed of indivisible parts; 3—the proof by the same Mendel that fertilization and normal plant development involve the union of one egg and one pollen-grain.

While Johannsen's beans and Mendel's peas have become classical, Mendel's second contribution has remained almost unknown. In a seminar course "based principally on outstanding contributions that have marked great advances in the theory and the application of genetics," we have retrieved this Mendel experiment, locating the account in the eighth of the ten letters from Mendel to the German botanist, Carl Nägeli.[1]

It is interesting that Mendel conducted his experiment in 1869, five years before Oscar Hertwig observed the fusion of egg and sperm nuclei of sea urchins and thus discovered the basic principle of fertilization.

How little understood this principle was only seventy-five years ago can best be appreciated by quoting that passage of Darwin's[2] which caused Mendel to undertake his experiment:

[1] "Gregor Mendel's Briefe an Carl Nägeli, 1866–1873," Herausgegeben von C. Correns. *Abhandlungen der Mathematisch-Physischen Klasse der Königlich Sächsichen Gesellschaft der Wissenschaften*, 29: 3, 235–236, 1905.

Quatrefages has shown in the case of the *Teredo,* as did formerly Prevost and Dumas with other animals, that more than one spermatozoon is requisite to fertilize an ovule. This has likewise been clearly proved by Newport, who adds the important fact, established by numerous experiments, that, when a very small number of spermatozoa are applied to the ova of *Batrachians,* they are only partially impregnated, and the embryo is never fully developed; . . . With respect to plants, nearly the same results were obtained by Kölreuter and Gärtner. . . . The pollen-grains of *Mirabilis* are extraordinarily large, and the ovarium contains only a single ovule; and these circumstances led Naudin[3] to make the following interesting experiment: a flower was fertilized by three grains and succeeded perfectly; twelve flowers were fertilized by two grains, and seventeen flowers by a single grain, and of these one flower alone in each lot perfected its seed, and it deserves especial notice that the plants produced by these two seeds never attained their proper dimensions, and bore flowers of remarkably small size. From these facts we clearly see that the quantity of the peculiar formative matter which is contained within the spermatozoa and pollen-grains is an all-important element in the act of fertilization, not only in the full development of the seed, but in the vigour of the plant produced from such seed.

The following is Mendel's own story of his experiment:[4]

Because of my eye trouble, I was unable last year to undertake further hybridization experiments. Only one experiment appeared to me so important that I could not make up my mind to postpone it to some later date. It deals with the view of Naudin and Darwin that a single pollen-grain is not sufficient for an adequate fertilization of an egg. As experimental plant I used *Mirabilis Jalappa,* as did Naudin; the result of my experiment, however, is an entirely different one. I obtained from fertilization with single pollen-grains eighteen well-developed seeds and from them as many plants, ten of which are already in bloom. The majority of these plants are just as fully developed as those derived from free self-pollination.

A few specimens, however, have until now lagged somewhat in growth, but to judge from the success of the others, the reason can only be found in the circumstance that all pollen-grains do not possess the same faculty to fertilize; and, furthermore, that in these particular experiments the competition of other pollen-grains was excluded. Where several compete, we may assume that always the strongest succeeds in alone effectuating the fertilization. However, I intend to repeat these experiments; also one should be able by an experiment to ascertain directly whether in *Mirabilis* it is possible for two or more pollen-grains to participate in the fertilization of one egg. According to Naudin at least three would be required!

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[2] Charles Darwin, "Animals and Plants under Domestication," Vol. 2, Chapter 27, pp. 435–436, 1868.

[3] M. Ch. Naudin, "Nouvelles recherches sur l'hybridité dans les végétaux," *Nouvelles Archives du Museum d'Histoire Naturelle,* Paris, Vol. 1, pp. 35–37, 1865.

[4] Excerpt from a letter written by Gregor Mendel to Carl Nägeli, dated July 3, 1870. (Translation from German.)

FACILITATE HUMAN ENDEAVOR THROUGH COLLEGE TRAINING IN SCIENTIFIC METHOD

Dr. Anton J. Carlson makes several points in his statement about Dr. Cattell's service to science[1] that need a lot more emphasis: (1) "Scientific method should be applied to all fields of human endeavor; (2) education (even in the sciences) is largely memory conditioned by traditions and faith rather than by the exercise of reason based on understanding; (3) human curiosity, human want and human pain are potent spurs; (4) keep your mouth shut and your pen dry till you know the facts."

Most of us will agree with the good doctor "that all men should have a good workable knowledge of scientific method," but he would be the first to point out, I am sure, that thus far the percentage of men who could thus qualify would be very small indeed.

The scientific attitude or viewpoint is comparatively rare, my observation forces me to say. The responsibility for this rests, in part, on our schools and colleges —or on what Dr. Carlson calls "the 'Quiz Kid' ideal of *what* rarely proceeding to the *evidence* and the factual *why.*"

To capitalize on human curiosity, instead of stifling it as happens so often in our schools now, I suggest that our colleges offer a full year's course in "Scientific Methods," and that such a course be required of all freshmen.

The accompanying outline covers the essentials of such a course, I submit, because it is basic, fundamental, broad in scope and provides orientation through the active participation of leaders in the various fields of endeavor. It is my thought that every college student should get an idea (1) of the mechanics of thinking, analysis or research, both technical and market; (2) of what is being done in research in biology, chemistry. geography, physics, marketing, etc.; (3) of statistics, semantics, logic; (4) of personal aptitudes; (5) and that he should learn when to keep his mouth shut.

A Tentative Outline of a Year's Course in "Scientific Method":

(1) Spirit and basic principles of scientific inquiry (2).
(2) Current research activities, needs, opportunities (4).
(3) Isolation and statement of problems (1).
(4) Technical and market research methods, public opinion polls (6).

[1] Science, 99: 2565, 158, 159.