ability level, on the average, than this national group. The results of this research also suggest that, although on the average the students taking the new course are somewhat abler than the students who typically take high school chemistry throughout the nation, there are substantial numbers of students among the CBA population with scores in the lower scholastic aptitude ranges.

How did the CBA group perform on the achievement tests designed for the new course? Data obtained thus far indicate that the course materials are being communicated to the hoped-for degree. The tests, which, in the opinion of the authors of the course, reflect the kinds of student learning stressed, were designed with the expectation that the average student would get about half the questions right. Table 2 gives a summary of the performances of the sample of 972 students who took all of the tests during the academic year 1960–61.

It is interesting to note, in Table 2, the descending pattern of correlation between results on the CBA achievement tests and results on the scholastic aptitude tests. The correlations (not shown in the table) between results on one CBA achievement test and those on another are equally interesting and consistent. The correlation for "neighboring tests" is relatively high, whereas the correlations for tests separated by large periods of the academic year tend to be low. The reasons for this phenomenon and for the descending pattern of correlation between the CBA results and the scholastic aptitude results are not entirely clear. Similar patterns have been obtained in connection with the Physical Science Study Committee high school physics course.

All the evidence to date suggests that the original goals of the CBA project are within reach. Data from the evaluation studies indicate that this course is appropriate for high school, and appropriate for a student group with a broad spectrum of abilities. In a few colleges where the course has been used, teachers report that the course is appropriate regardless of a student's major field—whether it be chemistry or English literature. Moreover, the results of the CBA study to date clearly indicate that we have vastly underestimated the potential capabilities of the American high school student. The evidence is clear that, even though modern theories of chemistry are used throughout to explain observed chemical phenomena, the course content *can* be effectively communicated to students of a wide range of scholastic abilities. Thus, the chemistry course developed by the Chemical Bond Approach Project, together with similar studies in physics, mathematics, and biology, should go a long way toward developing citizens who are far better informed in the scientific humanities than the average citizen is today.

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What Is To Be the Function of the Section on Statistics?

In formulating its plans and purposes a new scholarly group must consider activities of existing societies.

Jerzy Neyman

At the last annual meeting, in December 1961 in Denver, Colorado, the Council of the AAAS authorized the organization of a new section, Section U (Statistics), and Morris Ullman was appointed section secretary. At the forthcoming annual meeting, in Philadelphia, Section U will appear as an independent body, with its own program of sessions. These are described elsewhere in this issue (see p. 1148). The evening session of Saturday, 29 December, will be given over to a discussion of plans of future activities of Section U; this article is intended as preparation for that discussion.

Ordinarily, creation of a fresh scientific society follows recognition of the need for a new organizational framework—perhaps a minor revolt—on the part of a group of scholars who feel that the existing societies do not provide them with adequate facilities.

Frequently this occurs when a new, fertile subdomain of an earlier broad domain of research suddenly bursts into existence and attracts a considerable number of scholars. Such was the origin of the Institute of Mathematical Statistics. Such, also, must have been the origin of the Ecological Society, of the Society for Study of Evolution, and of others. The viability of a new scientific group depends very much on the importance of the novel domain of study, on the number of active scholars attracted by it, on the energy of the organizers, and on the services provided the membership. These services are, generally, an adequate forum for discussions and a specialized channel for publication.

To anyone who follows the developments of scholarly life in any modern country, the process described must be familiar. Its consequences are, broadly, twofold. First, except for those cases where the newly created societies are not viable and quickly die out, availability of the new facilities is accompanied by a vigorous development of a domain of research. Second, a further step is made toward compartmentalization of knowledge. The first of these consequences is undoubtedly advantageous. As to the second, there is

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considerable room for discussion. On the one hand, it may be argued that compartmentalization is unavoidable because of the tremendous volume of contemporary knowledge, and furthermore that it is desirable as a prerequisite of progress. On the other hand, it is argued that compartmentalization leads to detailed study of the proverbial trees with a complete disregard of the forest. Also, it is difficult to deny that, even in a very narrow area of research, substantial progress can sometimes be achieved if a difficult problem is examined from a broader point of view, particularly if this creates the possibility of borrowing a method developed by another discipline.

The summary answer seems to be that, while compartmentalization of research is unavoidable, contacts among the compartments and efforts at unification and at establishing an overall picture of contemporary science are a necessity. At the very least, under penalty of complete loss of horizon, efforts must be made to produce integrated pictures of separate broad domains of study. In addition to the popularization of science, efforts to unify science and to provide contacts between the compartments may be considered the primary purpose of the American Association for the Advancement of Science.

It seems to me that purposes and plans for AAAS Section U must be examined from a point of view suggested by the foregoing general considerations. One question to be answered is whether Section U is to be considered a novel organization of statisticians. This would be justified if there exists a subdomain of statistical research for which the existing societies do not provide adequate facilities. If this is the case, then Section U could adopt this particular subdomain as its specific field of activities. A second question that requires answer is how to organize the work of Section U so that the section can fulfill appropriately its role as a part of the AAAS, as an interdisciplinary forum.

Should Section U Become a New Statistical Society?

Regarding the first question, as to whether there exists a subdomain of statistical research requiring new facilities, my personal answer is that I do not know of any. The field of theory of statistics is very adequately covered by the Institute of Mathematical Statistics (IMS), with its journal, *Annals of Mathematical Statistics*, totaling over 1600 pages per year and still growing. In this activity the IMS overlaps a little the activity of the giant American Statistical Association (ASA). The latter, representing a great number of specializations, has a membership list filling a volume of impressive size and a journal, the *Journal of the American Statistical Association*, almost as large as the IMS's *Annals*. The diversity of research accommodated and furthered by the ASA is well illustrated by the program of its last annual meeting in Minneapolis, Minnesota, in September. The subjects discussed ranged from the authorship of the *Federalist Papers*, through problems of meteorology, intricacies of inductive inference, optimal experimental designs, problems of biology, government statistics, and educational statistics, to forecasts of economic developments. Then, in addition to the IMS and the ASA, there is the International Biometric Society, with its two "Regions," the Eastern North American Region and the Western North American Region. Also there are the Econometric and the Psychometric societies, the Institute for Management Sciences, the Operations Research Society of America, the American Society for Quality Control, and so on. All these societies deal with particular fields of application of statistics, and many of them publish well-established journals.

In these circumstances it is difficult to visualize a domain of statistical research requiring novel facilities that AAAS Section U could usefully sponsor. Moreover, if Section U is regarded as an association of statisticians at large, without a specialized field of activities, the section will become an organization competitive with ASA and, perhaps, with IMS. Because of the vigor of these two societies, the role of Section U would be reduced to that of a junior sister, with its membership composed mostly of amateurs. The conclusion seems to be that, in order to fulfill a useful role, Section U should carefully avoid anything that might place it in the position of a novel organization of statisticians. Instead, it should concentrate on activities, as an integral part of the AAAS, largely limited to the popularization and decompartmentalization of research. Here, the field is broad, fertile and most attractive.

Interdisciplinary Connections of Statistics

Although there were marked discontinuities in its development, modern statistical research was initiated in the late 18th and early 19th centuries by Laplace and by Gauss. Their statistical problems stemmed from a domain of applications which happened to be astronomy. Even though almost two centuries have elapsed since that time, probability and statistics are still close to fields of application and depend on them for novel problems. Naturally, there is a degree of reciprocity, and statistical thinking penetrates the work in science. Up to now this give and take has been largely accidental and has depended very much on personal encounters between workers in science, on the one hand, and those specialists in probability and statistics that have a liking for applied problems, on the other. Thus, there is room for an organized effort, one that Section U might usefully make, to bring scientists and statisticians together for exchange of information. The importance of such an exchange, and the current need for it, cannot be overemphasized. Here are two illustrations.

The importance of population genetics, now combining with ecology and with the theory of evolution, is generally recognized. It is interesting that its origin may be traced, apparently, to an accident through which G. H. Hardy, one of the founders of the modern British school of conceptual mathematics, became informed of the newly rediscovered Mendelian laws of inheritance. In 1908 Hardy published a short letter to the editor of *Science* concerned with gene frequencies under random mating. There followed large studies by R. A. Fisher, J. B. S. Haldane, Sewall Wright, and others, leading to the current state of population genetics and its appearance almost as an independent discipline. Similar examples of fruitful intellectual cross-fertilization can be found in many domains.

The same general field of genetics provides an example of the current need for exchange of information. While all statisticians are fairly familiar with the simple Mendelian law of segregation and, even, with the phenomena of linkage, mutation, and so on, they are less familiar with certain more modern developments in genetics. In particular, only rarely are

statisticians informed of self-sterility genes and only very rarely are they informed of anything relating to the genetics of bacteria. Statisticians with a taste for scientific research would welcome information on these and similar subjects, and it is quite likely that such information would lead to fruitful research.

Here is another example, of a somewhat opposite kind. At a recent seminar organized in a university department of physiology, a paper was presented concerned with currents between electrodes placed at different points in the bodies of cats. Using a high-speed computer, the author had calculated a host of correlograms and power spectra, which he exhibited to the audience. His concluding remark was, more or less, as follows: "I computed these spectra because Professor X [a renowned statistician] told me to do so. I believe that they contain all the information provided by my experiments. However, I wish I knew what they mean." The audience concurred heartily. Examples of incidents of this kind can be multiplied.

Exchange of Information Sessions of Scientists and Statisticians

Sessions at which scientists and statisticians exchange information do occasionally take place at meetings of statistical groups concerned with specific fields of application. However, to my knowledge such sessions are rare, and the papers presented and discussed at meetings of these societies are mostly given to solutions of some specified problems. This situation is, of course, quite natural. Thus, organization of sessions systematically given over to the exchange of information regarding substantive research that *presumably* involves interesting statistical problems, on the one hand, and developments in statistics and probability that *presumably* might be helpful in the given domain of science, on the other, is an open field of activity. Naturally, such a session cannot be expected to interest every scientist or every statistician. However, past experience indicates that some scientists and also some statisticians and mathematicians do become interested in each others' studies and that, in many cases, this results in considerable progress in research. Thus, it seems to me that if Section U adopts as its primary purpose the organization of meetings at which scientists and statisticians can exchange information, it is likely to fulfill a very useful role.

The organization of meetings for exchange of information between representatives of any mathematical discipline and other scientists presents many problems, some of them psychological.

In preparing to speak at a meeting, scholars invariably do their best to present some new, unpublished results of their own. Even if the paper in question is an invited paper meant to be expository, it is generally considered below standard if it is not based essentially on findings of the author. It is plain that such an attitude, perfectly natural at a meeting of a society concerned with the development of a given domain, would result in failure at a meeting for exchange of information between statisticians on the one hand and representatives of empirical sciences on the other. In the case of bacterial genetics, emphasis on novel findings of the geneticist is likely to be a sheer waste of time for the simple reason that the overwhelming majority of statisticians have no knowledge of the most basic facts. The same would be true for an expository paper for biologists by a statistician on, for example, ergodic theorems, with emphasis on mathematical delicacies of the author's latest generalization.

Another psychological difficulty should be mentioned. I personally observed it among scientists requested to give a talk for statisticians explaining an interesting cycle of phenomena. It is possible that statisticians experience a corresponding difficulty and that I did not notice it simply because I am a statistician. The essence of the difficulty is the presumption that a paper by a nonstatistician, in order to be interesting to a statistical or mathematical audience, must contain some mathematics. Because of this presumption many scientists decline to speak to statisticians. Their stated reason is, "I know no statistics"; from the point of view of exchange of information, this is no reason at all. Other scientists, under the influence of the same presumption, make a mistake of another kind. They agree to present the paper requested but, instead of concentrating on the nature of the phenomena and on experiments, dismiss these items in a few minutes and spend the rest of their time giving a not very satisfactory proof of a theorem that is well known to statisticians.

While difficulties of this kind are important and may be frustrating, they are secondary to the difficulty of selecting appropriate domains for discussion. Success will depend upon cooperation and discussions between the committee of Section U and groups and societies concerned with substantive domains. Also, breadth of horizon on the part of individual participants in these discussions is an important prerequisite for success. Finally—and this is the main prerequisite—the success of exchange-of-information sessions depends upon the availability of a sufficient number of scientists and of statisticians anxious to obtain the information that may be offered.

Secondary Purpose of Section U

While advocating exchange-of-information sessions as the primary purpose of Section U, I fully recognize the importance of other possible activities. Section U appears a natural instrument for exchange-of-information sessions simply because the annual meetings of the AAAS are ordinarily attended by large numbers of scientists whose normal activities on such occasions could easily be combined with attendance at an exchange-of-information session. However, something besides the exchange-of-information sessions must be provided if statisticians in any numbers are to be drawn to the annual meeting of the AAAS. One possibility (and this appears preferable to others) is to arrange for some kind of regional meetings of the appropriate statistical societies—IMS, ASA, the Biometric Society, and so on—to be held in conjunction with the annual AAAS meeting. Section U could cosponsor all or some of the sessions, and the statisticians could attend the exchange-of-information sessions of Section U and the usual statistical meetings as well.

If, for one reason or another, it proves impossible to combine the sessions of AAAS Section U with meetings of appropriate statistical societies, Section U itself will probably find it necessary to organize a few purely statistical sessions, including sessions for contributed papers. While this solution may appear the simplest, in my opinion it is much less desirable than

the first, for the reason that Section U would be taking the first step toward becoming a new statistical organization, competitive with ASA and IMS.

The foregoing discussion concerns the presumably more difficult part of a possible program for Section U—that concerned with the "advancement of science." The other part, concerned with the popularization of knowledge, can also be rich. Here we may think of sessions for informing the general public and other groups within AAAS of the use of statistics in various domains, including governmental agencies; of successful statistical studies in science; of the meaning of indeterminism; and of the nature of statistical tests, of methods of estimation, and so on.

The development of a scholarly group depends upon a number of factors and in the early stages it is difficult to visualize all the likely avenues. The plan for Section U sketched here appears to be an attractive possibility. However, there may be other possibilities. The time and place to consider them is 29 December in Philadelphia, at the evening session of Section U.

NEWS AND COMMENT

Supersonic Transport: Next Step in Civil Aviation Is a Difficult One

Sometime before next summer, the administration plans to announce whether it will seek federal funds for the development of a wondrous and costly machine, a civilian supersonic transport (SST) that would travel at least 1400 miles per hour and perhaps as fast as 2000 miles per hour.

Officially, the question of federal involvement is an unsettled one, pending the completion of studies by the Federal Aviation Agency. But under the pressures of Soviet-American rivalry and competition within the Western world, it is a virtually foregone conclusion that the decision will be to go ahead. Since the required technology is on hand or within sight, the almost certain result is that within a decade an American SST will be in commercial operation. Of far less certainty, however, is the question of whether the SST, like a 400-mile-an-hour passenger car, may not be so technically marvelous as to be out of touch with the social and economic world in which it will have to fly and, hopefully, earn its way.

Considerations of this sort have never before been of much concern to the airline operators, who have literally thrived on speed; but the virtue of the SST—providing speed of an entirely new order—is also the source of considerable doubt about the wisdom of an immediate commitment to an accelerated program of development, at a cost estimated between $500 million and $1 billion. (Unlike previous civil aircraft developments, the SST's development will have to be wholly government financed, since the manufacturers who would like to build it are generally acknowledged to lack funds to develop a prototype.)

Those who hold these doubts readily concede that the ultimate arrival of the SST is desirable and inevitable. At issue are the questions of how soon, and in what order of priority among the various needs of air transportation.

Although there is no shortage of cocksure assertions on every aspect of the SST, the realm of certainty is a fairly small one, a point that the FAA takes pains to emphasize in response to demands that it hurry up and say yes. The demands emanate mainly from the aircraft manufacturing industry, which has been brought to lean days by the missile and by the high productivity—and hence the requirement for relatively low numbers—of subsonic civilian jets. The potential customers for the SST, airline operators, are yet to recover from the immense cost of their rapid conversion to jets, and, while they pay due homage to the SST's speed, their attitude appears to be one of morbid fascination.

This is perhaps best understood when it is noted that U.S. international air carriers last year managed to ring up a net loss of $1.1 million out of operating revenues of $722 million; that British Overseas Airways was $140 million in the red in its last fiscal year; that the 18 scheduled airlines on the North Atlantic run, the most heavily traveled international route, were able to fill only 57.4 percent of their seats during the tourist month of July; that domestic trunk lines are gratified that their combined deficit for the first 9 months of 1962 is only $6.2 million, compared with $14.3 million for the same period last year; and that the industry's interest on loans now totals $90 million a year.

Against this gloomy financial background there stands the overwhelming certainty that, all other things being equal or not radically different, the SST's incredible speed would quickly draw passengers away from slower competitors. At 2000 miles per hour, it would travel from New York to Los Angeles in 1 hour and 40 minutes, as compared with the present 5-hour travel time of a subsonic civilian jet; and it would cross from New York to London in 2½ hours, cutting close to 4 hours off the best commercial speeds now obtainable. But there is no guarantee that all other things will be equal or not too different, and from these doubts arises the question of whether the SST will be a technical triumph and a financial flop.

For example, at this stage, despite pat assurances to the contrary, there is considerable doubt as to whether the SST will be more or less economical to operate than the subsonic jets with which it will be competing. This is a critical issue, since the airlines' path to economic health lies in the direction of lower costs and lower fares. A fast trip at a higher price would unquestionably appeal to those travelers who consider cost secondary to convenience, but it would not bring the masses flocking to help the airlines pay for their SST's.

There is also no certainty that the sonic boom problem can be reduced