Letters

Rhythm Method

May I be permitted a word in reply to Potter's criticism (*1*) of my article "Child spacing: The mathematical probabilities" (*2*).

The problems of mothers of two, three, or four children who wish to avoid further pregnancies during a risk period of 10 years or more have been well dramatized in Potter's published work (*3*). The monthly security factors needed here, 99.9+ percent, put this situation outside the attainable reach of the rhythm method.

The period of postpartum amenorrhea is not necessarily infertile (*4*). Tietze's (*5*) equation for the monthly security factor (*2*, Eq. 3) is valid for random coitus. It is also valid in a rhythm situation when the expected date of ovulation *cannot be known with accuracy*. The application of Tietze's equation would not be valid, as Potter correctly points out, after ovulation *is known with certainty* to have occurred during the current cycle (however, I have evidence of one pregnancy which occurred by isolated coitus 4 days *after* the temperature rise).

My article pointed out that Tietze's equation was "too pessimistic, from the standpoint of spacing births, when couples can be reasonably certain that ovulation will occur regularly in the middle of the cycle" (*2*, p. 1631). Even if the monthly risk of pregnancy predicted by Tietze's equation is cut down by half, it still takes only four to seven acts of coitus per cycle to get down to the 93-percent monthly security level at which spacings of more than 18 months between births become improbable.

Tietze and Potter's (*6*) theoretical analysis of the calendar method is based on statistical *models* of the menstrual cycle. These models account only for normal variations in the day of ovulation. They take no account of erratic variations which can result from sickness or emotional stress or of delayed ovulations which can be triggered by coitus.

The cautious Ogino-Knaus calendar proposed by the Planned Parenthood Federation based on make-believe cycles of 23 to 33 days would not have been proof against the following two facts, personally known to me, of conceptions which occurred by isolated coitus, one on the 4th day, another on the 33rd day of the cycle. Furthermore, such a calendar hardly leaves room for more than two acts of coitus in the cycle, and that at times when coitus is psychologically and aesthetically least desirable. I have evidence of cycles varying erratically between 19 and 74 days!

Nothing in Potter's criticism invalidates my conclusion that "the natural variations in the fertility and sterility of man and of woman will have to be learned and mastered, so that mankind can, in Pius XII's own words [*7*], take advantage of them."

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4. Centre d'Études Laennec (Paris Catholic Medical Study Centre), *La Regulation des Naissances* (Lethielleux, Paris, 1961).
5. C. Tietze, *Fertility Sterility* **11**, 485 (1960).
6. ——— and R. G. Potter, Jr., *Am. J. Obstet. Gynecol.* **84**, 692 (1962).
7. Pius XII, *Acta Apostolicae Sedis* **50**, 736 (1958).

The Trouble with Technological Forecasting

Technological forecasting is receiving increased attention in industry, in the Department of Defense, and in many other quarters. Forecasts, formal and informal, are fairly plentiful; their common fault, as I see it, is a reluctance on the part of forecasters to specify what science and technology are *working toward*. Forecasts are sometimes written as if the future growth of science and technology cannot be controlled, as if *laissez faire* will prevail in the future as it has, in great measure, in the past. The resistance of scientists, or any other group, in a non-regimented society to a directed or planned future is understandable, but it would seem that, in the interest of concreteness and coherence in forecasting, the assumption could be made that the needs of definable areas of scientific interest are broadly, if not in particulars, known today. Methodical forecasting could then have a framework of these basic steps:

1) Estimates of future requirements within definable areas (energy conversion, genetic control of biological organisms, and so on).

2) Predictable scientific discoveries pertinent to these definable areas.

3) Concepts, developed by applied research, looking toward applications.

4) Expected advances in technology that will permit the implementation of these concepts.

The imminence of scientific discoveries, fortunately for the forecaster, is often preceded by portents. Looking back to the discoveries that led to television, we can see that the promise of success was in evidence well ahead of the final victory. One phase of forecasting is, therefore, the identification of portents—no easy task but made easier if an application, however vague, can be visualized. Today, probably more than in the past, these "vague applications" are comparatively easy to find. They lie within definable areas—better physical materials, improved methods of energy conversion, novel means of transportation, the control and improvement of biological organisms, the extension of mental powers by mechanical means. The journals are replete with portents of advances in all these areas. Their identification and definition could conceivably be systematized.

In predicting the direction of applied research, the forecaster may have not a discovery, but only the prediction of a discovery. He then has to build the second story of his structure on top of a first story composed of gossamers (fortunately, the forecasts of applied research can also be composed of gossamers). Once a scientific discovery or set of discoveries has been made, identifying the type of research required to exploit the findings is a more clearcut, if not an easier, task. If the finding lies in the area of energy conversion, for example, the vague applications have moved along into much more concrete ones. But if the research prophet is asked to provide concepts whereby advances in—say—extrasensory preception could be exploited, sharper forecasting methods than any now available would be needed. Should it be shown that ESP is physico-chemical in nature, an immense amount of applied research would have to precede the invention of transmitting, receiving, and translating devices. . . .

Essentially, methodical technological forecasting calls for a better, sharper image of the future then we now have. It is curious that we have today a fairly clear set of requirements for making the moon habitable, as well as many concepts of the properties and characteristics to be incorporated into moon structures; the image of the future as regards planet Earth is less well defined. Research and development might be greatly benefited by improved statements of future requirements, complemented by technological forecasts of the general course that science and technology will take to fulfill them.

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Congress and the Fermi Prize

The Congress is composed of elected representatives of the people and is concerned with many and weighty decisions. Science is something few of its members understand, as is frequently pointed out in your columns. The actions of the Joint Committee on Atomic Energy in connection with the Fermi Prize [see News and Comment, *Science*, 20 Mar., p. 1305] are a prime example of their ignorant dabbling. Have they so little understanding of the devotion which is being shown by the many scientists who have consented to serve on such time-consuming bodies as the General Advisory Committee of the Atomic Energy Commission? Have they really the desire to keep good physicists from serving on it so that they may not become ineligible for some recognition?

I seriously suggest that the best action the General Advisory Committee of the AEC can take is simply to cease awarding the prize. If the Joint Committee cares, itself, to make an award to someone, presumably someone who has never worked for the government, perhaps (in order to avoid any suggestion of favoritism) not to a scientist at all, I suppose it is within its legislative ingenuity to do so. But I repeat, for the GAC the only dignified and proper action is to cease making the award.

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New High School Biology Course in the Light of Experience

In his fine review of the Biological Sciences Curriculum Study publications (*Science*, 14 Feb., p. 668), J. K. Brierley, one of Her Majesty's Inspectors of Schools, British Ministry of Education, voices some objections that others who have not actually used these books may share. We were among the high school biology teachers who evaluated the first revised Green Version textbook in their classes in 1961–62. Each of us evaluated in actual use one of the laboratory blocks (*Plant Growth and Development* and *Animal Growth and Development*). This year we have both been using the commercially prepared Green Version (*BSCS Green Version—High School Biology*, Rand McNally, Chicago, 1963), and we are currently evaluating a newly written laboratory block on *Metabolism*. We should like, in the light of this experience, to comment on some of the objections expressed in the review.

First, Brierley regards some of the concepts presented in the texts as too sophisticated and too difficult for high school students. Our experience is that all these concepts can be taught *to some extent* to all our students. The slower learners are taught them without certain refinements of detail. New aids to teaching biological concepts to the slow learner have been developed by the BSCS under the heading of "Special Materials." We have found that population dynamics, taxonomic theory, energy relationships, genetic continuity, and a host of other so-called "difficult" ideas of biology can become a part of a student's understanding even though he has reading or learning difficulties.

We think, with Jerome Bruner, that "it may be that nothing is intrinsically difficult," that "We just have to wait until the proper point of view and corresponding language for presenting it are revealed," and that "The trick is to find the medium questions that can be answered and that take you somewhere" (*The Process of Education*, Harvard Univ. Press, Cambridge, 1962, p. 40). It seems to us no disadvantage to have intricate diagrams in the textbook on which to base our questions for the more able learners; it is easy enough to ignore a diagram, a paragraph, or a whole section if it is not appropriate to the learner's ability. We are finding that it is not beyond the ability of the average student to extract and analyze chromatographically the purines and pyrimidines of yeast nucleic acids. The hydrolysis and synthesis of polysaccharides, autoradiography in photosynthesis studies, and the role of ATP in energy transfer are becoming first-hand experiences for our biology students. We have been amazed ourselves at what they have been able to do in what could reasonably be called "high level" biology.

Second, Brierley seems to misunderstand one premise of BSCS. He says that school courses should be complete in themselves and assumes that BSCS has prepared its curricula with this in mind. This is not quite true. It is true that for many students the high school course is the first and last formal presentation of biology; but to behold in the BSCS publications an effort to open and close the subject within the course of an academic year is to misunderstand our aim. The most basic attempt in science teaching is to prepare students for the great advancements that will come in the future. As a corollary, we must also rebut Brierley's conjecture that the BSCS includes too much physics and chemistry for average 15- and 16-year-olds. By and large, we find that our students are able to understand those bits and pieces of chemistry and physics that are introduced for clearer understanding of some of the biological concepts. We contend that the more relationships we can show among the natural sciences as well as among the specialties within biology, the better.

Our third comment is that the BSCS courses are *not* too difficult to teach even when one's formal education ended 20 years ago. Brierley says, "The impact of this new work on older teachers whose university courses were finished, say 20 years ago, and whose body of knowledge . . . may be largely inadequate and as obsolete as notions 'of body humors, the ether, or the impenetrable atom,' would be to break their backs and perhaps destroy the solid work they are doing in the