presumably every cycle of inflation will end in an eruption of some kind. To predict exactly when and where the next eruption will occur while the volcano is still inflating, however, is impossible on the basis of our present knowledge. As shown by Fiske and Kinoshita (*3*), the volcano goes through a number of cycles of accelerated inflation during general inflation, many of which are not followed by eruption. In particular, the tilt and level data continue to show "normal" changes in the days, weeks, or months preceding an eruption. The horizontal strain may, in time, permit longer-range prediction. It has been pointed out elsewhere (*3*) that, during the inflation associated with the last center of uplift, the horizontal deformation was far greater than would be expected from any model proposed to fit the level and tilt data.

Although more data on horizontal strain during eruptive cycles are needed, monitoring of these strains in the summit area appears to give the most favorable criteria for prediction of a few weeks. About 1 month before the eruption of 5 November 1967, high strains were noted in the area south of Halemaumau. This area, as shown by the level and tilt data, was the last area to inflate before the eruption and the first to subside at the beginning of the eruption. If we calculate cumulative strains from July 1966, the month in which a complete series of geodimeter measurements of the summit was begun, we find that the strains recorded along the lines south of Halemaumau exceeded average linear strains of 1.3×10^{-4} in the month before the eruption. The next highest cumulative strains at that time were about 0.9 to 1.1×10^{-4} along the lines east of Halemaumau. Many data obtained over longer time intervals are needed to determine the significance of the cumulative strain values. A program for monitoring horizontal strain at intervals of 1 week has been initiated at Kilauea summit in the hope that eventually it will be possible to predict volcano eruptions.

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Prognosis for the Development of New Chemical Birth-Control Agents

Parochial attitudes in technologically advanced nations make prospects increasingly dismal.

Carl Djerassi

The very rapid rate of increase in the world's population, notably in the developing countries, has become a matter of worldwide concern. Fifteen years ago this was virtually a taboo subject, whereas the term *population explosion* has now become a household phrase. Symptomatic of the international concern with this problem and its enormous economic, political, and human implications is the fact that the very first report by the Committee on Science and Public Policy of the National Academy of Sciences dealt with the population problem (*1*). A veritable flood of articles and books has appeared on this subject in recent years, and the general consensus is that effective family planning must play a key role in the solution of this world problem.

At first glance, the prognosis for improved family-planning methods appears promising. During the past 10 years a major breakthrough in birth-control techniques has been achieved: the development of orally administered contraceptive agents (*2, 3*) of virtually 100 percent effectiveness, and greatly increased use of improved intrauterine devices (IUD) (*4*). Both approaches lend themselves much more readily than conventional earlier methods (for example, the diaphragm, the condom, and so on) to broad-scale family planning in developing countries, and it is not surprising, therefore, that the well-publicized large-scale programs in such diverse countries as Chile, Egypt, South Korea, and Taiwan are based virtually exclusively on steroid oral contraceptive agents (*5*) and IUD's. Abortion is another effective means of population control, as demonstrated during the past 20 years on a country wide basis in Japan and eastern Europe, but the general tendency in research has been to concentrate on improved chemical agents for birth control, the dramatic effectiveness of the steroid oral contraceptive agents having provided the main impetus. Thus, considerable effort is being expended on overcoming one of the major drawbacks of these chemical agents—the necessity of taking a pill daily or with short interruptions—by developing "once-a-month" pills, or sustained-action formulations (Silastic implants, pellets, and so on) effective for many months or conceivably even years. Philanthropic organizations such as the Ford Foundation and the Population Council have been dedicating increasing amounts of money to the support of such research, and, during the past year, the National Institute of Child Health and Human Development of the U.S. Public Health Service has organized a Center for Population Research whose annual multimillion-dol-

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lar budget will be devoted to "the development of a variety of new methods of fertility regulation."

When we consider that such research has become not only respectable but also very fashionable, that ample financial resources are being mobilized by government, industrial, and philanthropic sources, and that the urgency and magnitude of the world's population explosion is widely recognized, then the prospects for the development of new or improved chemical contraceptive agents appear rosy indeed. My purpose in this article is to demonstrate that one factor, which has generally been overlooked and which is of rather recent origin, makes the prognosis for the introduction of new agents a progressively more dismal one. The Pugwash Conference, with its wide representation from developed and developing countries, appears to be a particularly suitable arena for airing this sensitive problem, especially since the topic "problems of population growth" has been put on the agenda of the 19th Conference in the context of "modern science and developing countries." As I intend to demonstrate in what follows, it is precisely this juxtaposition of "modern science and developing countries" which is creating an increasingly inhibiting atmosphere in the area of practical birth-control research if we equate "modern science" with "scientifically advanced nations."

While many of my comments also apply to newer work on improved IUD's, notably those containing metal or other chemical ingredients, I restrict my presentation to the development of newer *chemical* contraceptive agents (*6*), since this is a research field in which I have been personally involved, directly or indirectly, for nearly 20 years (*7*). All of the currently used orally or parenterally administered contraceptive agents are steroids, but it is reasonable to assume that clinically effective nonsteroidal organic chemicals (especially in the area of abortifacients) will also be developed. Irrespective of their chemical structure, there are at least six special or even unique factors that must be taken into consideration.

1) *Scientific complexity.* To judge from past experience, the development of an orally effective or parenterally administered sustained-action contraceptive from the chemical laboratory to final clinical use is one of the most complex sequences in medicinal research. Chemical investigations on steroids are performed in comparatively few laboratories (most of them large drug firms), and the large-scale synthesis of steroids is one of the most difficult of industrial chemical operations. The biological screening of potential candidates requires a very high level of sophistication, since the reproductive processes of the female and male are so complicated and involve so many endocrine as well as target organs. Examination for possible toxicity has to be of a long-term nature [the most recent U.S. Food and Drug Administration (FDA) requirements for animal tests establishing safety for chemical (*6*) contraceptives require testing for 10 years in monkeys], and not only must clinical trials be performed with large numbers of human subjects for long periods but they must also be accompanied by batteries of chemical laboratory tests in order to evaluate the effect of such contraceptive agents on many physiological parameters. The obvious conclusion is that such research, especially if it is of a pioneering nature leading to development of new contraceptive agents or approaches, can and will be done only by scientists from highly developed, scientifically advanced countries. Therefore, the fact that virtually all such work has so far been performed in North America and Europe is not surprising. In other words, the research and development work is being performed in those countries in which the population increase is the lowest, in which conventional birth-control measures have already been used for a long time, and—most importantly—in which it is possible to dispense with new birth-control measures without concomitant disastrous economic consequences.

2) *Time scale.* By definition, if a contraceptive agent is to be used for family planning rather than as an adjunct to occasional sexual intercourse (for which, incidentally, "post-coital pills" are currently under investigation), it will be employed by an individual for long periods, frequently over many years. The statement is frequently made, notably in the lay press, that agents such as the female oral contraceptive pills will be taken by a woman for periods exceeding 20 years and that nothing is known about possible side effects resulting from such prolonged usage. While it is perfectly true that experiments on several thousand women would have to be conducted for 20 years in order to yield an unambiguous answer to such a question, our accumulated experience during the past 10 years shows that, given a receptive climate for the development of new agents, very few women would in fact remain on the same contraceptive pill for even 10 years. Nevertheless, every responsible investigator will grant that unusual caution must be exercised in the toxicological and clinical evaluation of such agents, and that statistically meaningful experiments on large numbers of women for reasonably long periods must be conducted before such drugs are released to the general public. In a recent private conference in our laboratory with several experts in biology and clinical medicine from the United States and Europe, it was concluded that more than 8 years would be required to satisfy all current U.S. FDA requirements for introduction of a new agent to the public—once the chemical and initial biological work had been completed. These initial studies are by no means trivial and would themselves entail 1 or more years; thus a new contraceptive agent, in order to be introduced in 1977 as an effective means of population control, must already, in 1969, have passed through the chemical and biological laboratories of its discoverer. The demographic implications of this statement are rather shocking for a developing country that may still be waiting for the ideal contraceptive agent (instead of using existing ones) while its population doubles every 20 years, as is now the case in many areas of the world.

The apparent need for new contraceptive methods is exemplified by the following quotation from an editorial in the *New York Times* (6 July 1969) on the world's population proliferation:

> Although recent advances in contraceptive technology—notably the pill and the loop—have made possible dramatic reductions in the birth rate in a few small countries, efforts at population control have been disappointing so far in most of the developing world. Many demographers believe that if significant reductions in population growth are to be achieved there must be a technological breakthrough in contraception similar to that in food production.

This desire for new contraceptive agents seems to stem from the observation that, in large-scale studies in developing countries, the 2-year dropout figure with IUD's or with the steroid oral contraceptives exceeds 50 percent. Personally, I am not convinced that any better results can be obtained with any method which requires a conscious act

Table 1. Risk of death with various contraceptive methods. [From *Int. Planned Parenthood Fed. Med. Bull.* **2**, No. 4 (1968)]

Method	Pregnancies (No.)	Women aged 20–34 years (10^6 users per year)		Women aged 35–44 years (10^6 users per year)	
		Deaths due to pregnancy	Deaths due to method	Deaths due to pregnancy	Deaths due to method
IUD	30,000	7	Not known	17	Not known
Oral contraceptives	5,000	1	13	3	34
Diaphragm	120,000	27	0	69	0
Safe period	240,000	55	0	135	0
Pregnancy	1,000,000	228		576	

of conception control. For the populations of these developing countries it will be necessary to develop a procedure which produces, by a single administration of a birth-control agent, indefinite (but reversible) sterility, which could then be overcome temporarily by administration of a second, "fertility-producing" drug. The general state of the adult human population under these circumstances would be one of infertility which could be changed only by a conscious act, rather than the reverse state of affairs existing now. In the light of my subsequent remarks about the increasingly negative climate and conditions for clinical testing of new contraceptive agents, it seems exceedingly improbable that such a new approach can be brought to practical fruition in this century.

The *New York Times* editorial statement that "there must be a technological breakthrough in contraception similar to that in food production" must be viewed against this realistic background. Such remarks are frequently made in scientific as well as lay circles, but they are superficial. Improvement in food production (notably the recent dramatic results in wheat and rice production) is a technological matter which does not affect the palatability, acceptability, or biological properties of the food. A more appropriate analogy with respect to new contraception technology would be one between recently achieved improvements in food technology and improved chemical methods of manufacturing contraceptive pills, which would lower their price but would hardly affect population growth. Conversely, an appropriate counterpart in the food technology field to the required technological breakthrough in contraception would be the development of a completely new food (for instance, a synthetic food), whose acceptability to different populations would first have to be established, and whose mode of administration (for example, in pill form) would be quite novel. If solution of the world's food problems depended on such a basic technological development, then the prospects for solving them in this century would be rather dismal.

3) *Side effects and healthy population.* Items 1 and 2 are basically logistical ones, and we can now turn to some of the more sensitive issues emanating from the fact that the contraceptive approaches to be utilized in the underdeveloped parts of the world are in fact being discovered and developed in the most advanced nations. We are faced with the ironic situation that, in these advanced nations, in which sales of tobacco and alcohol are not restricted in spite of the serious "side effects" of these agents, new candidates for contraceptive agents must meet more rigorous standards than most other drugs. One of the reasons is the assumption that the use of contraceptive agents involves healthy individuals and that only absolutely minimum side effects can, and should, be tolerated. Such a position is illogical on several grounds. First, our society does not take such a position with much more dangerous agents such as alcohol and tobacco, in spite of the fact that no socially redeeming effects (for example, birth control) are associated with their use. Second, there really are no drugs that have no side effects; even aspirin has known gastric effects and causes occasional deaths (*8*). Third and most relevant to our topic is the fact that pregnancy itself, which the contraceptive agents prevent, is a condition (some women might even call it an illness) that is accompanied by side effects ranging from nausea to death (see Table 1). My thesis is that we cannot afford the luxury of such rigorous standards, which are probably unrealizable (it seems unlikely that a drug lacking side effects in a few individuals can ever be developed) and unrealistic (requirements of 10 to 20 years' clinical experience with human subjects prior to general use have been proposed by some circles, though not yet by government regulatory agencies), unless we are prepared to accept the reality that no new chemical birth-control agent that meets these standards will ever be developed.

4) *International role of the Food and Drug Administration.* The protocols for, and the conduct of, clinical trials in the United States have to be submitted to the FDA, which can disapprove them. This is the agency which subsequently approves or disapproves a drug for marketing. Except for export of drugs, its mandate ends with the geographical boundaries of this country. Yet in actual fact its dominant role is now noted over most of the world (especially in Europe) and even recognized by the FDA itself through the establishment in 1966 of an Office of International Affairs (*9*). Irrespective of the reasons, a drug that is formally disapproved in the United States has little chance to be marketed in Europe, and in the field of the steroid oral contraceptives the FDA has a *de facto* veto power in most European countries. The consequences of this situation are particularly serious in the field of birth control.

The FDA is a government regulatory body which is subject to tremendous political, journalistic, and legislative pressures. In a way, it is remarkable that the FDA has managed to maintain a considerable amount of independence even though many of the pressures exerted upon it have nothing to do with scientific facts. As stated above, the FDA's policies and standards for final approval of new contraceptive agents affect the possibility of even conducting initial clinical trials in the United States, and even abroad. For understandable reasons, FDA personnel have no incentive for expediting approval of new drugs, because their primary mandate is to protect the public from harm and fraud, rather than to stimulate medical advances. Consequently, the more novel the drug or mode of administration, the more extensive the data the agency requires for approval. The expense involved in conducting drug trials and in obtaining FDA approval in the United States generally runs now to millions of dollars and thus leads to the inevitable, albeit unfortunate, result that only very large commercial organizations have the financial and technical resources needed for carrying a new drug all the way to final, clinical use by the public. Expeditious FDA approval of a new

drug, were it possible, would be looked upon by the press and the public today as kowtowing to a profit-hungry enterprise. And there have been unsavory examples that encourage caution. Unfortunately, this atmosphere has a particularly devastating effect on the development of new contraceptive agents.

These drugs, it should be noted, are really the first medicinal agents to be administered for very long periods to essentially healthy individuals, and neither the FDA nor the medical community has as yet solved satisfactorily the problem of what the standards should be in evaluating a drug used in such a population group for such purposes. This question must be answered eventually, because the trend in modern medicinal research is toward preventive medication, and in many conditions of aging and deterioration—for instance in atherosclerosis—the ideal preventive will have to be given to "healthy" individuals many years in advance of the actual occurrence of the disease.

Approval by the FDA (or occasionally by some European equivalent) is a virtual *sine qua non* before any contraceptive agent is accepted for wide use in one of the developing countries that have no significant governmental drug-control agencies, and the standards and designs of the clinical and even biological experiments are adapted to the American milieu. This situation occasionally has very unfortunate consequences in the birth-control field. Let me cite three examples, all very different.

The first illustrates the fact that epidemiological factors tend to be ignored, since drug approval is sought within the context of the American, or Western European, population. Thus, in Egypt—a country in which most of the government-supported birth-control programs are based on oral contraceptives —there seems to be an abnormally high incidence of liver involvement (*10*) after the use of steroid oral contraceptives; this, on further reflection, is not too surprising in view of the prevalence of *Bilharzia* infection in that country. In Iran, galactorrhea as a consequence of administration of the oral contraceptive (*10*) has been reported relatively frequently, whereas such a complication is seen very rarely in Europe or the United States. Under the present circumstances, such epidemiological factors will be studied only after a drug has passed the 10-year screen of FDA approval, which, of course, is much too late.

A second example illustrates the combined effect of general legal restrictions and FDA requirements. For perfectly understandable reasons, the FDA requires evidence that new drugs do not have teratogenic effects. While some tentative conclusions can be derived from animal experiments, the ultimate answer must come from human experience. Even the layman will recognize that agents affecting the ovum or sperm may present risks in that regard, and that it would be highly desirable therefore if, in the event the contraceptive agent being tested failed to prevent pregnancy, the pregnancy could be terminated through abortion and the fetus examined. In the United States and many other countries, such a procedure is legally impossible, and, as a result, initial clinical experiments with really novel "once-a-month" pills, which require access to potential abortion, cannot be conducted in the United States. The consequences of conducting such clinical work abroad in countries where it is permitted are considered below.

The third example illustrates what is potentially the most dangerous consequence, one arising from the fact that there exists no independent scientific body to which FDA scientific decisions can be appealed. Under certain circumstances, the FDA may wish to appoint an ad hoc advisory body of experts, whose decisions are not binding on the FDA, but there exists no independent group to whom the experimenter can appeal if he (rather than the FDA) wishes to do so. The need for such national and international appeal bodies is great in the field of birth-control agents, for the following reason. The single biggest bottleneck in fertility-control research is the lack of a satisfactory test animal, other than man, for evaluating efficacy and safety. Despite this lack, the FDA has recently imposed very special requirements for animal testing of female contraceptive agents (requirements quite distinct from those for other drugs)—one of them being the stipulation that toxicity studies with very high daily doses be made in dogs for 7 years and in monkeys for 10 years before large-scale clinical trials are permitted (*11*). The motivation, on political and even humane grounds, is understandable, but the scientific rationale for selecting these animals, notably the dog (whose semiannual heat cycle and notorious sensitivity to female sex hormones hardly allow meaningful extrapolation to the human female with her monthly menstrual cycle), is highly debatable. Thus the World Health Organization Scientific Group (*3*) reached the following conclusion about animal studies with steroid contraceptives:

> The extrapolation to women of data derived from dose and duration studies in experimental animals is of questionable validity and may be misleading, particularly when it is impossible to assess the comparability of dosages and lifespans. In the light of these considerations, the interpretation of such data is extremely difficult. *There is no evidence to justify recent emphasis on the presumed advantages of observations in subhuman primates and in canines* [italics mine].

In spite of this scientific uncertainty, requirements that long-term tests be made in dogs have, to my knowledge, resulted in the recent discontinuance of at least two clinical trials of promising compounds. Even more serious is the fact that, as a consequence, this experience with FDA's practical power to determine scientific protocol has led one of the largest of American drug companies (which does not market any contraceptive agent) to discontinue virtually all research on contraceptive agents chemically related to female steroids. This self-imposed restriction may not be regretted by competitive drug firms, but it is certainly unfortunate as far as general scientific advances in population control are concerned, because this company's research organization is internationally recognized as being among those at the very top. There is little doubt that if the present climate concerning clinical testing of contraceptive agents had existed 15 years ago, none of the steroid oral contraceptives now being used would ever have been developed.

My prediction is that, as the FDA-imposed requirements for clinical testing of contraceptive agents become more and more complicated, increase costs enormously, and are not appealable (except through the courts) to an independent body, new companies will not enter the field, and existing ones with a very heavy commercial stake in the field will do less research (most of it of the "me-too" variety because of the somewhat lower risks of failure to secure official approval), and the resulting vacuum will not be filled by anybody else. Under these circumstances, the newly organized NIH Center for Population Research may well stimulate interesting basic research in reproductive physiology, but this will hardly result in development of a

practical birth-control agent before the next 3 billion human beings are added to the world's population.

A partial solution to this problem—one that could be easily implemented in the United States—would be the appointment by the National Academy of Sciences of a permanent body of independent experts to whom questionable scientific decisions of the FDA with respect to animal and clinical testing could be appealed, and whose conclusions would be binding on the FDA.

5) *Foreign clinical experimentation.* Irrespective of the justification for prohibition, once clinical trials with a drug have been prohibited in the United States, it is difficult to resume them elsewhere. As a result—and this is particularly true of contraceptive agents because of the additional testing requirements imposed by both the United States and Great Britain as compared with requirements in the testing of other drugs—more and more of the preliminary clinical trials, following the initial chemical and biological studies, are performed abroad, frequently in one of the developing countries. Regardless of the caliber of such work, it takes little imagination to predict what kind of major issue can develop from such a state of affairs, in which preliminary trials on human beings, under the auspices of technically advanced countries, are performed first in developing countries.

6) *Implications for population control in developing countries.* Regardless of the site of initial clinical experimentation, there is no doubt that, on moral and political grounds alone, a new chemical contraceptive agent to be used on a massive scale in a developing country must also be approved and used on a wide scale in the country of its origin (the United States or a European country). For all practical purposes this means that, in most instances, it must have passed scrutiny by the FDA or one of its European counterparts (for example, the Dunlop Committee in Great Britain), with all of its advantageous protective safeguards but, also, unfavorable bureaucratic delays. The moral and political justification for such a stand is fairly obvious. The advanced countries are not only the ones from which new contraceptive agents emanate technically; they are also the ones that supply motivation and even pressure, coupled with financial and technical assistance, to the developing countries for the introduction of family-planning programs in which such contraceptive agents are used. These advanced countries are placed in a virtually untenable position when they propose the use of agents and procedures which they, themselves, are not prepared to use on their own populations (*12*). On a smaller scale, this is the objection to conducting initial clinical trials abroad.

It should be remembered that, even under ideal circumstances, the motivation of technologically advanced countries (generally countries of white population) preaching the family-planning gospel to the developing countries (frequently of nonwhite population) is highly suspect. Even within the United States, some of the economically deprived black inhabitants of our urban ghettos attribute genocidal motives to family-planning programs in their areas.

With these factors in mind, it must be realized that any position taken in the United States or Europe on presently used or potentially interesting future contraceptive agents has repercussions which extend far beyond the borders of these countries, and has worldwide consequences as far as population control is concerned. Thus, in the United States, the more recent reports on an apparent relationship between the use of certain oral contraceptive steroids and thromboembolism leading to deaths in a very small number of individuals appears in the press under headlines like "Pill Kills," with implied or specifically stated criticism of the fact that their use in the United States continues to be permitted. Even if one accepted all these deaths as an established consequence (*13*) of the use of steroid contraceptive agents, the data in Table 1 demonstrate that the number of deaths is still far fewer than those associated with pregnancy. Indeed, even if the number of associated deaths were ten times as great, a strong logical case could still be made for the continued use of these steroids as lifesaving agents.

Of particular relevance is the observation that a statistically meaningful causal relationship (*13*) between thromboembolism and steroid contraceptive agents could be suggested only after extensive use by several hundred thousand women, since the incidence is in any event so very low. It is probably quite impractical to anticipate or even demonstrate the occurrence of other side effects of such low incidence in clinical trials (as compared to actual clinical practice), because the scope of such an experimental project in terms of number of subjects as well as duration of experiment would simply be too vast and would make it exceedingly difficult to bring to practical fruition any really novel chemical approach to contraception, be it in the female or the male. If major advances in fertility control are to occur, we must realize—and so must the regulatory agencies of the technically advanced countries—that some risks should be willingly undertaken in promoting and facilitating widespread clinical trial and reasonably prompt practical use of such new agents, risks commensurate with scientific caution, but caution unencumbered by bureaucratic inertia. Otherwise, with every passing year, the accumulated burden and penalties associated with a bulging world population become more severe.

Conclusion

In a thought-provoking article on the population problem, Berelson stated (*14*) that "what will be scientifically available, politically acceptable, administratively feasible, economically justifiable, and morally tolerated depends upon people's perceptions of consequences." Within the narrow scope of the present article—namely, the prognosis for the development of new chemical birth-control agents—no degree of politically acceptable, administratively feasible, and economically justifiable motivation on the part of the developing countries will lead to new advances in contraception unless the technically advanced countries, foremost of which is the United States, recognize that their virtual scientific monopoly in the field of reproductive physiology imposes upon them a moral and logical obligation to take a global rather than a parochial view of novel contraceptive approaches. The pivotal role for future developments anywhere in the world rests to a considerable extent on government agencies such as the U.S. Food and Drug Administration, whose legal mandate is the protection of the national, rather than the international, population within the confines of national rather than global problems. Such a parochial view may perhaps be tolerated in research dealing with specific diseases, but its consequences will be disastrous when applied to a problem like the world's population growth.

Indeed, it is not fair to place the entire onus for satisfactory scientific designs of clinical protocols, scientific

evaluation of clinical data, permission for eventual use by the general public, and continuous subsequent monitoring of the drug (in the present case, the contraceptive agent) on one agency, which can hardly fulfill all these partially competing functions in an objective manner. As far as the prospects for the development of better birth-control agents are concerned, the Achilles heel seems to be the presently unassailable ultimate authority of government regulatory agencies to pass judgment on scientific matters. The more questionable the scientific fact is, the more questionable this single scientific authority becomes. In view of the extraordinary scientific complexity and the many unanswered scientific questions in the field of human reproductive physiology, which cannot await leisurely answers because of the enormity of the problem of population growth, the ultimate authority on such scientific matters (especially during the experimental preclinical and clinical phases) should rest on independent bodies of experts to whose scientific judgment the governmental regulatory agencies as well as the investigator are prepared to bow. Since the appointment of membership to such "final courts of scientific appeal" is such a delicate matter, my recommendation is that the national responsibility in the United States be delegated to the National Academy of Sciences, and that the international responsibility be delegated to the World Health Organization. In fact, the World Health Organization already has such groups (*3, 4*) consisting of experts from developed and developing countries. All that is needed is to bestow on them the necessary authority.

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2. C. Djerassi, *Science* **151**, 1055 (1966).
3. "Hormonal Steroids in Contraception," *World Health Organ. Tech. Rep. Ser. No. 386* (1968) (report of a WHO scientific group).
4. "Basic and Clinical Aspects of Intra-uterine Devices," *World Health Organ. Tech. Rep. Ser. Nos. 332* and *397* (1966; 1968) (report of a WHO scientific group).
5. The cost of the agents themselves is no longer a critical factor, since, in such large-scale government-sponsored projects, it has already reached the level of 10 cents per woman per month.
6. For the purposes of this article, the conventional foam tablets, jellies, and the like are not considered within the definition of "chemical contraceptive agents."
7. My association with this field has been through Syntex Corporation, a commercial organization of which I am a director and president of the research division, rather than in my capacity as professor of chemistry at Stanford University. This connection may raise some question, perhaps reasonably, as to the objectivity of my remarks. However, this has also given me a kind of practical experience that is not readily available to anyone who has not been directly involved in the commercial development of pharmaceuticals for wide public use. I would also add that my own strong feelings about the importance of finding practical solutions to the world population problem have been a primary incentive in my work and in my efforts to bring my views to public attention. Therefore, I hope that any criticism will be directed at the content, rather than the source, of this article.
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9. K. E. Taylor and C. O. Miller, *FDA Pap.* (1968), p. 27.
10. E Diczfalusy, Karolinska Institute, Stockholm, personal communication.
11. E. I. Goldenthal, *FDA Pap.* (1968), p. 13.
12. In retrospect, it is interesting for me to recall a series of lectures that I presented in Sweden in September 1962 under the auspices of the Swedish Chemical Society, dealing with the development of steroidal oral contraceptives. Sweden had at that time not yet approved oral contraceptive steroids for domestic use, yet, as part of its impressive and intelligent foreign assistance program involving population control measures, it was already promoting with great vigor the use of such contraceptive agents in certain Asian countries. In my lectures I emphasized the moral and logical objections to such a position.
13. The medical community seems by no means to be unanimous on this question; see L. E. Moses, *J. Amer. Med. Ass.* **208**, 694 (1969) and references cited therein.
14. B. Berelson, *Science* **163**, 533 (1969).

Language Universals: A Research Frontier

Empirical limits of logically possible types provide a basic method for linguistic generalization.

Joseph H. Greenberg

The number of languages in the world may be estimated as between five and ten thousand. This vast linguistic diversity is but one facet of human sociocultural diversity in general. The term "universal" is well established in cultural anthropology and sociology to designate those properties of human cultures which are found in all groups; for example, tool-making and the existence of organized social institutions and belief systems. Lists of such panhuman cultural traits have been drawn up from time to time by cultural anthropologists. The following is a well-known example of such a list: speech, material traits, art, knowledge, religion, society, property, government, and war. Each item furnishes a component of a "universal culture pattern" as described by Clark Wissler in 1923 (*1*).

It will be noted that each of these items is a highly general rubric, such as might form the topic of a chapter in the ethnographic description of a particular people. To posit the existence of universals of this type involves the assertion of the basic comparability of all cultures. As minimal as such a claim may seem, it is in fact a basic achievement of the last century of anthropology to have demonstrated that all human groups, however simple their technology, possess coherently structured institutions which include functional equivalents of all the basic categories of the technologically most advanced societies. Indeed these results have still not fully penetrated popular consciousness. For example, in respect to language, it is still widely believed that the languages of the technologically simpler peoples are themselves simple and lack fully articulate sound systems and well-defined grammatical rules.

It is obvious that such a list as that of Wissler cited above lacks specificity in that it merely asserts, for example, that all peoples have speech and government without delimiting in any fash-

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