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John Morfit, for STAP distribution

To :

FROM : Joshua Lederberg

SUBJECT: Which biological technologies are likely to have the most profound world impact within the next 10-25 years?  
(Preliminary response to Steve Lukasik's request at last STAP mtg.)

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There really needs to be an n-dimensional scale to locate the various contingencies: the dimensions would include the likelihood of an event, the variance of that likelihood (perhaps expressed in the confidence limits of the time of its accomplishment), the scope of the consequences, and the extent to which they would set up differential stresses or advantages in the world community.

The most likely events are in the development of constructive health and agricultural technologies.

On the health side the most important developments will concern an extension of population-control-technology (which has already had important demographic consequences in the advanced countries) to the point where they provide at least access and opportunity to population limitation to the LDCs. It is difficult to predict the actual course of development of population policy country by country, but it seems likely that an eventual if sometimes grudging acceptance of the need to limit population growth will be adopted universally. Countries that aggressively move in different directions may indeed be targets for concern about their political expansionism.

Parallel to population control we can look forward to continued improvements in the control of epidemic disease: the most important from a global economic standpoint are malaria and schistosomiasis. There is considerable uncertainty about the time required for effective control but a 15 to 30 year outlook is perhaps a reasonable one. The net result of the successful deployment of these technologies (and again there are many social and cultural as well as technological factors!) may give improvements in infant survival that almost balance population control measures. The net result may - optimistically - be some reduction in the overall rate of population growth of the LDCs but unquestionably this will remain at a higher level than in the advanced countries. It would be important to try to produce a country by country demographic projection for, say the year 2000, that includes various levels of optimism about these technological changes. (The control of these debilitating more than lethal diseases should have the most positive economic impact on the LDCs.)

Most students of the world population problem have been obsessed by the global consideration and have given little attention to the specific international stresses that disparities in population level will undoubtedly unleash.

It may be too optimistic to believe that we can learn the rules of social technology that may permit more rapid aculturation of currently deprived peoples - this is a piece of or perhaps embraces the general technology transfer question - but I do not think this possibility should be thoroughly discounted. The PRC for instance has shown notable successes in certain areas along these lines, and I believe one could find a very few successful

experiments among the large number of failures that go under the label "We Don't Know How". (If you do not know the book by the Paddocks under this title, I strongly urge it on you. It is a general critique of so-called international aid programs). *with important implications for technology transfer to LDCs*

For most of the LDCs the problem of aculturation of existing agricultural technology will probably be the major hurdle, so there may not be too much point in talking about the purely technical advances that are possible in this realm. There have been several studies of new food resources that may become available for tropical countries (see the NAS surveys on these questions), and there is little doubt that there could be an enormous technical payoff for crop development and other agronomic studies in these areas. And we have, of course, a vicious cycle, namely that more insightful work on the biological side that could give these technical fruits is discouraged in advance by the difficulties of securing their social adoption. Conversely, if therefore we could see some successes in the latter sphere, there would be even more progress on the biological side!

The northern hemisphere is less constrained by these social factors, and I am confident that we will see major advances in the style of agricultural research and corresponding strides in the applications of new biology for crop development. Hitherto difficult problems like the adaptation of crop plants to arid climates, brackish or salt water, or short cold seasons will not in my view be so difficult to surmount once there is an effective use of modern findings and concepts from molecular and cell genetics. This point seems to be well understood in the PRC (judging from reports from their Institute of Genetics); we are beginning to wake up to it in this country although we have had a sleepy agricultural research program for many years; I am a bit more at a loss right now to judge the status of Soviet agricultural research along these lines. This was blasted for a generation by the Lysenko disaster, but for the past 10 to 15 years I have been saying that it is on the point of rejuvenating although I do not have a clear picture of its vigor at the present time at the interface between molecular genetics and crop development.

Albeit one should factor in the likelihood of these technological responses in any world model that sees global economic changes driven by possible climatic change, which at the moment is speculative, or by the more obvious shifts in the cost of energy inputs to agriculture. Even the climate models are too simplistic: regardless of whether one accepts the temperature effects, one also has to keep in mind the distribution of rainfall which is a more complex problem and not easily predicted. The water resource availability may prove to be an even more critical consideration than the mean temperature. And there may of course be efforts at climate modification that (1) can alter the national impact of the global model and (2) may well become the source of further international conflict.

A number of ambitious projections for health improvements in this country might be made, and some of them would have significant social and economic consequences. We might perhaps achieve a lengthening of mean longevity by say another 5 years (probably offset by some reduction in the female over male advantage with the increasing equalization of life-styles). This prolongation of the period after middle age will undoubtedly exacerbate the social stresses of the "problem of the older people" but is not likely to be as large a factor in international relations as the demographic changes of the LDCs. (Consider how much more stressful inflationary transients are the longer lifespan). To attain even a 5 year prolongation would imply marvelous successes in the fields of prevention of heart disease and

of cancer but not their total eradication: these are perhaps median optimistic expectations for the next 25 years.

On the negative side, without attaching a very high probability (that is more than 25%) a number of possible catastrophes need to be given far more careful thought than they have been: they include pandemics and crop failures as a result of global plant disease.

The swine influenza fiasco may make it even more likely that we will get into serious trouble when a real villain comes along. Presumably such pandemics would have much greater impact on the populations of LDCs - with poor health facilities - than on the richer countries, but there are some circumstances where the opposite might be true. If for example the virus of hepatitis A were to become much more virulent, pre-existing immunity in low-health-status countries might afford considerable protection. In my view, both the national and the world systems of protection against infectious disease are pitifully inadequate in the face of any such major challenge. Nor is there any theoretical reason to believe that such viruses will not evolve and indeed, as already hinted, improved hygiene itself may set the stage for a broader base of susceptibility to certain agents.

The current trends of social control of laboratory work on microorganisms - <sup>use</sup> which I believe the excitement about recombinant DNA is just a beginning - will of course tie our hands even further in the development of effective responses to these contingencies. The appropriate comment about the Philadelphia outbreak of "Legionnaire's Disease" has not yet been voiced: the extent to which it is a testimony to the frailty of our investigative capabilities.

As long as we are discussing such <sup>civil</sup> catastrophes we perhaps should mention contingencies like the release of radioactivity (from nuclear mishaps) or of poisonous chemicals (like TCDD in northern Italy recently), but on almost any model of the potential for damage from natural epidemics is many orders of magnitude more severe.

Rather similar comments can be made about crop disease: these have been elaborated in the NAS report on genetic factors in aggravating the susceptibility of agriculture to disease outbreak.

Finally - although I believe less likely than natural infections - one of course must also contemplate the possibility of BW with comparable consequences. Anti-personnel BW is almost certainly the unique province of terrorist or crazy state activity, but nevertheless can hardly be totally discounted. Anti-crop warfare, as part of a protracted conflict - like the Sino-Soviet one - can hardly be ignored. The most likely contingencies for the use of such weapons would be at a time when other events might seem to predispose to revolutionary change; or as an adjunct to low-level continued hot warfare. The very limited experimentation by US forces on the use of chemicals to deny guerilla forces <sup>in VN</sup> access to food supplies illustrates the setting in which crop diseases might well be attempted by parties not effectively constrained by current treaty commitments. Besides the theater implications of such attacks, the possibility of spillover into the world food supply is of course the gravest concern.

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The possibility of a clandestine attack upon US agriculture by such means deserves continued attention as well. Such an attack might be motivated by general motifs of vengeance or resentment - probably primarily on the part of some national groups - or might be an effort to deny the nation the economic advantages of having a corner on the supply of a major grain. On this reasoning the end of the spectrum that is occupied by cattle and corn would be more likely targets than wheat. It would be rather easy to introduce hoof and mouth disease into this country in a way that would entail enormous economic costs that would be born almost uniquely by the country itself. In fact, one could conceive of such an attack being motivated by nothing more than economic interests on the part of other countries who have been barred from access to domestic US markets, many of whom already have hoof and mouth disease in their own stock.

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P.S. Collection implications:

↳ Overhead assets: for northward extension of cropping efforts

↳ Literature and other open data reviews: in re sophistication of application of new genetic methodologies to agricultural problems. (I am waiting for some existing documents on this theme before formulating possible commitments to further studies.)

The 1978 Intl Genetic Congress in Moscow may be a major opportunity to assess the status of current work in plant genetics. I hope USDA attaches are encourage to attend overtly with perhaps some briefing and debriefing on these particular issues.

Have there been any official exchange visits on these themes?