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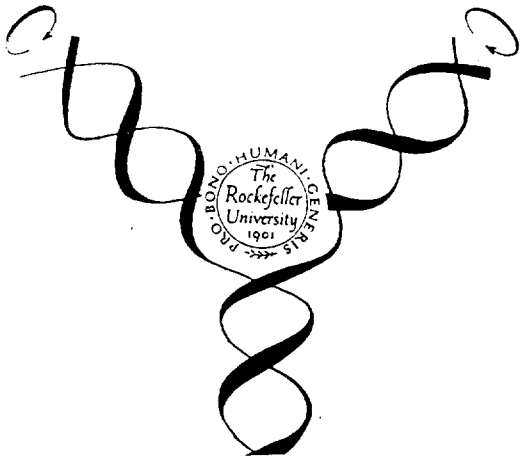

Newsletter from the Lederberg Laboratory

December 2, 1992

Dear Friends of the Lederberg Lab:

On this occasion, our topic will be some issues in science policy. This is especially timely during the period of presidential transition. The end of the cold war and the urgency of this country's economic recession will both enforce drastic changes in science and technology policy. Many people will wonder what's happened to our "peace dividend". At the same time, the phasing down of defense procurement and of the size of the armed forces is leaving many people hunting for jobs. One of this country's great strengths has been the vigor of its basic science. Many people in Washington are asserting that science must be more effectively harnessed to technological applications, and in turn to economic productivity. This is a laudable goal; but there will be much frustration and mischief if there is not a clearer understanding of how basic science is done, and the ways it can be harnessed to a specific mission.

In biomedical science we have lived with these paradoxes for many years. Although, the improvement of human health is understood to be the guiding goal of our research, we have also understood that all the easy paths, for example, for the cure of cancer or of AIDS, have been heavily trodden long since. This is not like the more applied engineering project of spaceships to the moon. There we already knew exactly where the moon was -- more importantly, the laws governing its motion, celestial mechanics, had been well known for 200 years. We also knew fairly precisely how to build rocket engines, and could estimate (within a factor of five) how much it would cost and how long to build the necessary hardware. I don't underestimate the engineering skill and imagination that was needed -- but the achievability of the project was firmly grounded on existing scientific information.

Indeed, basic science is quite different. We start with tentative hypotheses, our models of what the world is like, and then try to devise tests to probe those ideas. We are constantly trying to overturn or to revise the "established truths", or to fill in areas of perplexity and darkness. Our greatest accomplishment (and joy) is when we have made an unanticipated discovery, when we are confident that we can discard our preconceptions, our experiments having shown that we were wrong, and we can revise our paths with greater confidence. This relentless criticism is at the very root of science: and we don't do it alone. The whole point of publication is to expose our claims and data to the scrutiny of the worldwide community of science. And they are more than happy to collaborate in this quest, by letting us know right away when we were on the wrong track. Sometimes we will get the courtesy of a few hours advance notice, but the entire process is highly public. And it is our obligation to be party to this objective and unceasing scrutiny, to volunteer all we know that might bear on the conclusion.

How different this is from, for example, trial procedure in our legal adversarial system. Here each side is expected to garner whatever persuasive tools and evidence it can for presentation to a third party jury. Neither will volunteer any more than it is obliged to, for that might be damaging to its case. The jury is, hopefully, impartial -- but what it is allowed to hear is constrained by rules of evidence that often have little bearing on the contribution of some facts: for example, evidence secured by unwarranted search. This, of course, is what to be expected when there is a tradeoff between the investigative process qua process and other important values like our constitutional guarantee against unlawful search and seizure.

In any case, a scientific finding will be judged by some objective test of its predictive power -- it is an insight into the laws of nature. A legal finding usually is concerned about a single historic event, and is necessarily validated by the community's more subjective sense of fairness and justice.

The detailed method of science is best illustrated by specific examples -- hopefully some of our Lederberg Lab "get togethers" in the future will highlight that. The most important thing to note for for now is that it is far from a linear process, marching predictably to rigorously defined goals. I have illustrated that with the following diagram. The term "epicycles" refers to the back loops on the circle -- what the ancient astronomers figured as the orbits of the planets, not knowing that earth and Mars were both circling the sun. The diagram displays how much of science is a backloop: hopefully 3 steps forward for every 2.9 in reverse; often even the definition of the problem will be revised as we encounter the experimental facts and derive new insights. Under the pressure of intense public interest in in the results of still unfinished studies, conclusions may be adopted before they have been critically validated. We see many examples of confusing about-faces in fields like human nutrition.

Political leaders may then be asking the impossible of basic science, if they seek a tangible pathway of applications and products that will affect, for example, the balance of trade. We badly need ever more innovative technology, but not at the expense of this substratum of scientific inquiry. In the short run, economic competitiveness will mainly depend on capital formation, efficiency in management, and better process technology, none of which, I admit, have much to do with basic science. But science can provide two irreplaceable things for us:

- A discipline about facing reality, a nature that is not amenable to sweet talk or self delusion
- The basis for long-term revolutions in technology that could not even have been foreseen at the time of discovery. Examples of the latter abound: all of electronics stems from arcane studies of subatomic particles. The laser from mathematical inquiries. Biotechnology from the roots of DNA structure and the natural history of breeding in bacteria and viruses.

The priorities for science policy have more to do with "science for policy" than "policy for science". Our nation and the world face innumerable problems crying out for compassion, resources, managerial and political skills, and a high level of scientific and technical expertise. Some of these are quickly summarized in the enclosed editorial. Procedurally, the first priority is for Mr. Clinton's transition team to come to grips with setting up the executive structures that will provide the highest quality of advice. In the technical arena that means ready access to the skills and the critical reaction of the scientific community. The so-called *Republic of Science* is just as important as the brainpower of individuals in providing science with its special brand of authenticity.

As a final note, I have enjoyed co-chairing the Carnegie Commission on Science, Technology and Government during the past 3 years. It has generated a number of reports that may be of special interest to some readers -- so take a look at the enclosed list.

With best wishes for the forthcoming holidays,

P.S. If you haven't gotten to it yet, it's not too late for your flu shots. The minor discomfort is a very good bargain to avoid the flu, and to help keep it from being passed on to others.

Epicycles of Scientific Discovery