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ASPECTS OF RESEARCH AND DEVELOPMENT

Ralph E. Gomory

Most of us who are here tonight as members of the Industrial Research Institute have spent a good many years in research or in development. We have come to learn through our own direct experience the true complexity of that world. We have learned that the right idea is only the beginning and that being wrong in detail can often be fatal; perhaps even that there's too early, as well as too late, in industrial research.

There is more that could be said, but I don't propose to describe in detail a world that you know as well as I do.

But there are many worlds beyond R&D, and we must deal with them to a greater or lesser extent. There is manufacturing, marketing, and outside the world of our own companies there are the worlds of academia, the various parts of government, the press, and the foreign countries; and, of course, the one that we're all most conscious of today, Japan. Now these other worlds, in contrast to R&D, are known to us usually only to a limited extent by our own direct experience; and much of what we know about them comes indirectly, very indirectly, through reading, through the press, by word of mouth, or through television.

Inevitably, much of what we know about them is over-simplified; and it is in fact quite capable of being quite wrong. And these mistakes can matter. Let me give you two examples.

If we accept a picture of a Japan Incorporated, of cooperating companies providing life-time employment to their employees, and organized and led by a far-seeing government, we may be dealing with a fantasy about a cooperative rather than a competitive society. But we may not be dealing effectively with the much more complex reality of a very different culture, of companies that are in fact fiercely competitive with each other, and with the reality of companies that in fact through a network of subsidiary companies have access to a very large labor pool that they can and do lay off, or the reality of excellent engineers who routinely work a 60-hour week. And of companies whose great strength is in fact not their much-vaunted cooperative research but, in fact, quality manufacturing.

Similarly, if we take at face value the simple view of the press that it itself presents—that its goal, however imperfectly attained, is to print the truth as objectively as possible, we will go on being puzzled by the fact that the articles on the subjects we really understand, such as our own research and development activities, are so erratic. We will continue to assume, for example, that because what we do is so complex and so technical the poor things, meaning the journalists, just can't quite get it straight. And we can then struggle to simplify our explanations even more, or to give the journalists special seminars to educate them; but we won't make much progress. But if we start to learn some of the realities of a reporter's world and of the necessity, from their point of view, of writing and rewriting, and even completely reformulating, their articles in order to make them appeal to their readership and command space in their own publications, then we may start to make progress.

The difficulty of forming a realistic view of other worlds than our own is certainly not confined to R&D. Consider academia. While those who are not well acquainted with the university world may deal with it in terms of very simple stereotypes, such as the ivory tower, or the absent-minded professor, the realities of the complex and even entrepreneurial academic life, the need to get support, the endless struggles over tenure and appointments, the strain and competitiveness as well as the excitement and achievement of research are certainly not lost on the practitioners. They know the reality and the complexity of their own world just as we do about R&D.

But when they look out, they see a simpler world; and very few in academia have any idea of the complexities of R&D. In fact, it's generally assumed that when you have a good idea it's rather simple to make it into a product. And that to a very large extent the idea is the whole thing. It is with conviction then that university researchers can advocate more support to universities as the main answer to the problem of increased international competitiveness.

A View of Manufacturing

This simplifying of the external view is characteristic of every world. Manufacturing is another example. In fact, a manufacturing man I once met, who of course fully understands the complexities of his own world and the complexity of high technology manufacturing, and whose whole life has been devoted to making things by the hundreds or by the thousands, once dismissed the

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entire effort of the R&D community with a single memorable phrase. He said, "Anybody can make *one* of anything."

We in research and development, aware as we are of the complexities of our own world, often suffer from the same almost inevitable egocentrism, and we tend to underestimate the difficulty and even the invention that are a part of manufacturing. And, of course, it's even easier to ignore the intelligence and energy required for successful marketing.

So the picture for all of us is very much that of the famous Steinberg *New Yorker* magazine cover. In the foreground is Manhattan. You can see the cars on Ninth Avenue; if you look closely, there are people, there are signs that you can almost read. But next is Tenth Avenue, somewhat less detailed; and then, in a rapidly receding view, the Hudson River. In rapidly increasing simplicity, we can see the West, the Pacific Ocean, and then, in barest outline, Japan.

For each of our worlds, it itself is the foreground and everything else appears stereotyped and somewhat over-simplified in the background. This then is the normal picture, and to some extent it must continue this way. We each have only one life, and this precludes our obtaining a direct and in-depth knowledge of many different worlds. On the other hand, the theme of this meeting is "R&D Meet Manufacturing." And it's also true that in and out of the IRI we see today many attempts to form strong and realistic ties to academia. So perhaps the picture will become slightly realistic in those two areas.

Finally, I'd like to say a few words about the concept of self-image. Some of the worlds that I've named project a very strong self-image, and others do not. Consider academia. The university researcher's own very strong personal conviction about the importance to the world of undirected basic research has been very effectively projected to government and to the press. I strongly believe that all of us have benefited from the resulting strong basic research capability of the country.

However, we have not been as effective about the role of R&D and technology; and we should change that. Let's think for a moment about what we do.

In spite of the label of applied science, which is often applied to our work, we could not for a moment make progress by simply taking a scientific idea and applying it. That just isn't real life. In reality, most of the objects that we deal with in R&D, be they the surfaces of materials or the complexity of a computer system, defy by their sheer complexity any scientific analysis. We make progress through art, experience, common sense, and by using our scientific knowledge on aspects and pieces of a reality that itself is usually far too complex to be analyzed. To make progress usually requires invention and often scientific invention. Knowing how to do this, and to make progress with these complex realities, is itself an art. And this is the art we practice and of which we should be proud.

What we do has another dimension, the dimension of achievement or effect on the world. During the next decade, as in past decades, we can expect from the efforts of our research and development laboratories new materials, new processes that will make familiar objects cheaper, probably another drop by a factor of ten in the cost of computing with all that that implies, and so on. We have a tremendous record and it will continue.

All of these things that come out of our laboratories are a contribution to the material basis of the world, and we have there an achievement which we can take pride in quite independently of its technical virtuosity.

In addition, we do all this in R&D under the discipline of profit, which means that the value of the goods we produce must always be greater than the values in materials, labor, and machinery that were consumed in making them. That's a very remarkable discipline. Our business is always to transform rocks into diamonds and never the other way around.

The world of research and development is very complex as are indeed each of the various worlds in which people live. There is much in ours that cannot be captured by any simplified image or any short statement whatsoever, but there is also much that is easily stated and in which we can take pride. With art, invention, and imagination we deal with the complexities of real and complicated objects. We add value to the world. We create the technologies that are transforming the world.

We should feel a sense of pride in such a profession; and as we do that, we will automatically project that proud view to others. If we do this, our profession will be strengthened, we will be strengthened, and we will be able to do more. □