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Innovation for Fun and Profit  
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Richard L. Garwin  
[RLG2@us.ibm.com](mailto:RLG2@us.ibm.com) [www.fas.org/RLG/](http://www.fas.org/RLG/)

I take my title from a book by Jacob Rabinow, *Inventing for Fun and Profit* (1990), as an example of the difference between innovating and inventing. Rabinow was a staff member of the US National Bureau of Standards, now NIST, who resisted promotion because he was so good at what he was doing-- creating solutions to problems, some of which only he recognized.

You see in me a great fan of innovation who has often tried to have people prize invention less and innovation more. Innovation takes place when one adopts a novel approach, whether it is a new invention or an invention at all. It might have been something practiced long ago, but forgotten.

One can innovate in materials, in procedures, as well as in things.

Look around you, and realize how much we owe to the unsung heroes-- the engineers who create and perfect high-quality cars, electronics, and ones that are affordable, as well. And to those who recognized an opportunity and persisted in finding a solution-- perhaps in some existing gadget or technology.

My late friend, Ed Purcell, Professor of Physics at Harvard, soon after the Second World War was asked to visit one of the major automobile manufacturers in Detroit (Ford, I think) and was taken behind the scenes to see the process of building and designing automobiles. The company then asked him to head a new research establishment, to do anything he wanted, no holds barred. Purcell was enthusiastic and said that he had many ideas for improving automobiles. But the company's enthusiasm vanished; they thought they had the automobile innovation and design process down pat. They wanted Purcell to do pure research.

Purcell shared a Nobel Prize in Physics for the invention of nuclear magnetic resonance techniques, and he played an important role in national security as a member of the President's Science Advisory Committee and as one of the great innovators in what was euphemistically called overhead reconnaissance-- both from aircraft and satellites. Purcell and I are named two of the ten Founders of National Reconnaissance.

I had my own experience with Ford when I was Director of Applied Research at IBM in 1965-66. Ford had sent out a call for new ideas, and I thought I had one that was just right. It would replace the nest of spaghetti that is the wiring in an automobile with a single command bus and a power bus. Every item that uses electrical power in the car would have an address, and it would be connected or disconnected from the bus by sending a command to that appropriate address. It is evident, of course, that Ford was not interested. They wanted new ideas in styling

and not in engineering. Now Airbus has now come a cropper with the delay of its A380, in large part because of troubles with the wiring harness.

Innovation can do great public good. Whoever noticed that eating rice and beans at the same meal provided far more nutrition than eating them separately made a great contribution. The amino acids of rice and beans complement one another in the building of the proteins in the body.

Tim Berners-Lee contributed mightily with the invention of what was to become the World Wide Web, as did Kerry Mullis, the inventor of the polymerase chain reaction--PCR.

But innovation is as important in making things cheap, if not new. Some companies have "Suggestion Award" plans that will give an employee 20% of the first-year's savings. I remember how unhappy I was when I discovered that there was no mechanism in one company to publicize the vast number of Suggestion Awards, so that savings could be realized company wide and not in just one's own plant.

When I sat next to John Tukey, fabled statistician from Bell Labs and Princeton, at meetings of the President's Science Advisory Committee, it was not just because of my respect and friendship for Tukey; truth be told, it is because I could eat some of his dried prunes. We worked together on photographic reconnaissance in a then ultra-secret panel headed by Edwin H. Land, inventor of polarizing film and instant photography. One day John Tukey was writing what I recognized as the sums of cosines. I had just finished an experiment with solid helium-three at very low temperature, compressed to double normal crystal density. I had done also a computer experiment on 20,000 nuclear spins to learn what regular pattern these spins arrange for themselves. But it would have taken me hours of costly computer time to visualize the result.

John Tukey had learned from a British mathematician and cryptologist, I.J. Good, of an approach that should lead to doubling the number of points in a Fourier series (a spectrum) without quadrupling the number of multiplications. And that was just what I needed. I arranged for Jim Cooley, numerical analyst at IBM Research, to work with John Tukey, and that was the origin of the Cooley-Tukey algorithm for the Fast Fourier Transform--FFT. Cooley managed to fit all the data generated by the computation into the space needed for the input array.

That algorithm is the basis of the compression that is used now on music and images in digital TV and MP3 players. In pre-FFT days, to compress a picture of a million pixels would have taken a trillion multiplications, and now it takes only about 15 million. It is not every day that one learns how to save a factor 100,000 in computational effort, and you can see what that means for the sequence of 60 images per second in digital TV.

It is good also not to stop with the first solution you find. A second lets you choose the better, and even check whether you have blundered. And it is highly productive to bring new people into a field, to apply their knowledge to a new problem. It is beneficial to them, too, because they may find new ideas to help solve the problems in their own field.

In some circles, innovation or even engineering is not highly respected. Somehow it is more important either to make lots of money or to work on more abstract questions of science philosophy. Designing for low cost or easy maintainability may not excite the technical person or even the salesperson as does design for performance or appearance, but it is as valid a way to enrich society. John Gardner had it right in saying,

"An excellent plumber is infinitely more admirable than an incompetent philosopher. The society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water."

Everywhere around you is an opportunity for doing good or making money by innovation. Companies should prize it, and individuals should get good at it. It really is fun and it can be profitable. Start now.

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