The critical role of creativity in research

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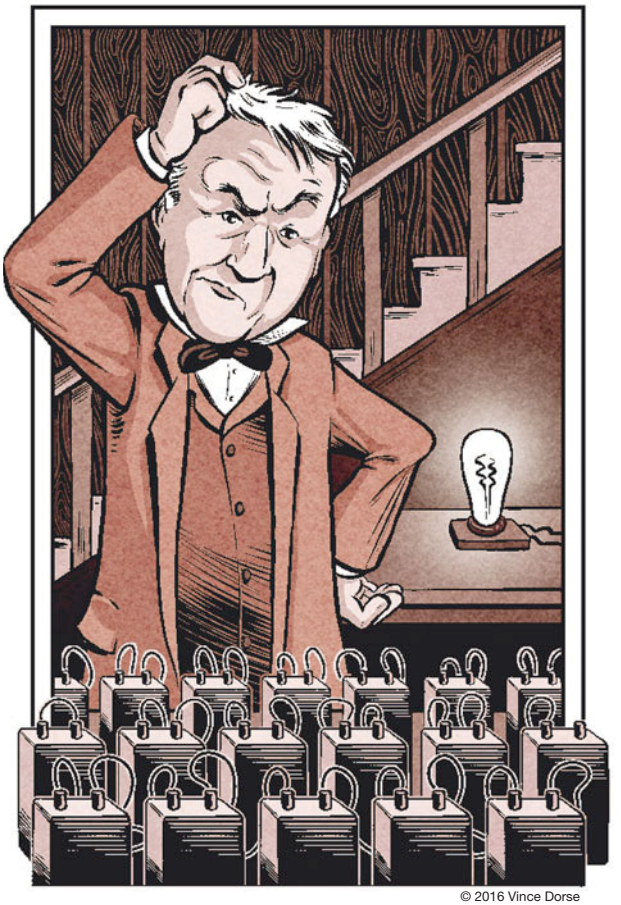

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As a senior doctoral student, I often motivate our research group in weekly meetings by bringing up important events, seminars, lab reminders, and anything that is worthy of discussion. A few months ago, I posed this question to our group (~30 researchers): "Does anyone have any crazy, out-of-the-box suggestions for how we can use this material?" Unfortunately, my question was answered with blank stares, a few confused looks, and a wall of silence. While we eventually had a discussion along those lines, it was clear that "out-of-the-box" thinking was not something that came naturally to us. But this unfortunate situation got me thinking about research today and where creativity and innovation fit into our research process.

By most definitions, creativity and innovation—while used interchangeably in many disciplines—are two different things. *Creativity* is defined as coming up with something original or unusual. Motivated by curiosity on top of a vast knowledge base, creativity allows one to shake up the normal way of thinking and come up with new solutions to a problem. *Innovation*, on the other hand, is creating something new that has obvious value to others. While we may have our own way of separating the two ideas in the world around us, I would posit that there is a very interesting space where both concepts can coexist and even complement each other: a *scientific research laboratory.*

At first, this might sound ridiculous. Aren't the creative process and the scientific process entirely different? Isn't innovation reserved for industry and product development? Perhaps, but, in fact, scientific research is a field where there are no rules, no standards, and no direct expectations of an outcome. Fundamental research is meant to discover the unknown and solve problems that don't yet have solutions. It often doesn't go as planned and leads to solutions and problems that were not part of the original question. In the modern world, the problems that science attempts to solve are also extremely complex, leading to more and more interdisciplinary fields and collaborations. For example, Materials Science is a naturally interdiscipli-nary field consisting of chemistry, biology, physics, math, and many engineering components. The nature of a materials science discipline is creative in itself, acknowledging the fact that problems such as self-healing polymers and energy storage cannot be solved with any one strict science discipline alone. These complex problems require complex solutions from scientists who can creatively combine their multiple fields of knowledge.

But how does innovation fit into a research laboratory? In many labs, it does not. Scientists who have run tests and analyzed results the same way for years are not likely to innovate. In fact, many researchers are moving too fast through what they know without considering what they don't know. They don't take a step back to ask if there is another way to get to the solution. While creativity in the lab can yield new ways of thinking about the problem, innovation can create new ways of solving it. In some cases, this may lead to a patentable idea or product, similar to the technology innovations we are familiar with today. For example, trying a new material in a completely different application could be considered innovative. But in most cases, it will be a new way of testing or a new way of synthesizing, and these small changes can have a large impact on research and our understanding of the scientific world.

So let's go back to my group's apparent confusion when they were challenged to be creative and innovative at our meeting. Why do scientists seem to be too busy to innovate? In industry, it makes sense to be cautious with new ideas because there are always budget limits, and funds need to be used where they create the best outcomes for the enterprise. But why hesitate to try a crazy idea in the lab when at the very worst it simply won't work?

An IQ test is a standardized measure of intelligence that has existed for decades.

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About 30 years ago, when raw IQ scores were analyzed, James Flynn discovered that the scores had been increasing over time.[1] This led to the "Flynn effect," a concept suggesting that people are getting smarter with each new generation. There are many suggested reasons for this trend, including increased levels of nutrition, longer years of schooling, and more stimulating environments. About 50 years ago, E. Paul Torrance developed a similar test to measure the creative intelligence of a person (Test of Creative Thinking). This test is also standardized to compare individuals with their peers. Recently at The College of William and Mary, raw emotional quotient scores were analyzed over time, revealing that people are becoming less creative with each new generation.[2] Despite the positive trend of the Flynn effect, a reverse trend is seen in creativity, suggesting that the technology and ease at which we can gather information today has reduced our need to think creatively.

A major factor that limits one's desire to take creative risks in their field is the fear of getting it wrong. We are repeatedly taught that there is a correct answer to every problem, and anything else is wrong. Therefore, trying something new and creative could seem difficult to scientists who are used to solving issues with a single focus. However, one of the most important discoveries was made after thousands of failed attempts. In a biography[3] of Thomas Edison, the author interviews Edison's associate Walter S. Mallory about these experiments:

> This [the research] had been going on more than five months, seven days a week, when I was called down to the laboratory to see him [Edison]. I found him at a bench about three feet wide and twelve feet long, on which there were hundreds of little test cells that had been made up by his corps of chemists and experimenters. I then learned that he had thus made over nine thousand experiments in trying to devise this new type of storage battery, but had not produced a single thing that promised to solve the question. In view of this immense amount of thought and labor, my sympathy got the better of my judgment, and I said: "Isn't it a shame that with the tremendous amount of work you have done you haven't been able to get any results?" Edison turned on me like a flash, and with a smile replied: "Results! Why, man, I have gotten lots of results! I know several thousand things that won't work!"

In science and especially research, getting it wrong is just as important as getting it right. Once we are able to accept that our creative idea might not work, but that is okay, we can unleash a whole new potential of creativity and innovation toward solving the world's problems.

Knowing that our environment and the wealth of accessible information are acting against our potential creative skills is only partly helpful. Acknowledging that one can be more creative in the lab is great, but thinking creatively is often a departure from the norm. A good example of creative science is something that has a large impact on the field and is simple enough that many people have had the chance to make the same discovery. For example, the isolation of graphene sheets from graphite has both of these characteristics. In 2004, Geim and Novoselov received a Nobel Prize for their work, so it was definitely influential to the field of materials science.[4] On the other hand, it was a very simple solution, consisting of simply cleaving layers of graphite using Scotch tape. It was something any scientist could have done without expensive equipment, but only these scientists did it, making their discovery creative. So next time when you are running a routine experiment that you have done a thousand times, stop to consider a new way you could do it, or daydream about different applications that could benefit from your new materials. But most of all, don't forget to learn as much as you can both inside and outside of your field. Do not let the scientific process and busy experiment schedules keep you from trying crazy, out-of-the-box ideas. There is no better time or place to be creative than a research lab.

I am providing some tips to increase your ability to be creative and innovative. Who knows, maybe you will solve one of the world's most pressing issues. You will never know unless you try.

Six tips toward increasing scientific creativity:

1. Knowledge is the basis for which creativity and innovation can develop. Make sure you are open to learning new things at all stages of the problem-solving process, since new information might be the key to finding a creative solution.
2. Take a break from the problem statement and let your mind wander. Research shows that by giving your mind time to focus on something else or to relax, you free your mind to come up with a newly innovative idea. In 1869, struggling to organize the chemical elements, Dmitri Mendeleev took a nap at his desk. While he slept, his subconscious mind kept working. In a dream he "saw a table where all the elements fell into place as required," and this was the basis of our current Periodic Table.
3. Open your mind. Perceptions and judgments can limit the information you take in. Don't let these feelings close your mind to a potentially creative idea.
4. Rewrite the problem in a completely different way. You might see the solution from this perspective. Or ask a friend for help! Another pair of eyes may be able to see the problem in a different light.
5. Try things others are not trying and look where they are not looking. Sometimes the answer is a creative twist on what people have not tried. Don't be afraid to be the one to give it a shot.
6. Don't be afraid to get it wrong. Research is the best avenue for taking risks because of the freedom you have to solve problems that no one has solved before. Edison made several thousand attempts before he discovered the one that worked.

References

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