Editorial

Case studies in innovation: What enables outstanding achievements?

Journal of Commercial Biotechnology (2010) **16,** 95–97. doi:10.1057/jcb.2009.38

In fostering innovation, be it in biotechnology or in another field, a persistent challenge is to understand the factors enabling success. It is not sufficient to simply be smart; plenty of smart people and smart teams fail to innovate. It is not sufficient to be diligent; plenty of hard-working people and teams likewise fail to innovate. Some also recognize that luck plays an important role. Louis Pasteur is famous for his statement, 'in the field of observation, chance favors the prepared mind'. Although none of these individual attributes can completely describe the qualifications for innovation, it is likely that outstanding achievement requires, as a minimum, a combination including all three. Another important consideration is that the drivers for innovation likely differ by field. To enrich my understanding of the topic, I recently had the opportunity to perform a case study of three exemplary innovators in diverse fields: the 2009 Kyoto Prize Laureates.[1]

The Kyoto Prize is an international award honoring those who have contributed significantly to the scientific, cultural and spiritual betterment of mankind. The prize foundation was established in 1984 by Kazuo Inamori, founder of Kyocera Corporation, who, in consultation with the Nobel Foundation, sought to complement the Nobel Prize with an award recognizing 'balanced development of both our scientific progress and spiritual depth'. More information on this year's and past laureates can be found on Inamori Foundation website at www. www.inamori-f.or.jp.

Given the exclusivity of the Kyoto Prize and the many people considered annually, the laureates must be more than simply brilliant, diligent or lucky. What are the elements that enable exemplary individuals such as the Kyoto Prize laureates to stand apart from their peers, who likely also demonstrate brilliance, diligence and some measure of luck? To further investigate this question, I present my observations of the laureates below.

Dr Isamu Akasaki was awarded the Kyoto prize in Advanced Technology for his work leading to the development of blue LEDs. After 16 years of dedicated research he was able to produce gallium nitride crystals, a feat that many others in his field held to be impossible. Dr Akasaki's rationale to pursue the crystallization of gallium nitride was that the characteristics of the compound promised to emit a bright blue light and enable blue LEDs. The addition of blue to the previously available red and green LEDs would enable semiconductor devices to produce the full spectrum of light, in all visible colors, including white. While prior efforts had attempted to employ other elements such as silicon carbide, the utility of these crystals was limited by weak light emission or poor durability. Two significant factors challenging the production of gallium nitride crystals were the high melt temperature of gallium nitride and thermal decomposition of the compound into gallium metal and nitrogen gas. This significant challenge also presented an opportunity; if the crystals could be made, the extreme conditions

required for their manufacture would also mean that they would be extremely resilient and able to be used in harsh environments. Figuring that claims about the impossibility of producing gallium nitride crystals were merely other researcher's desire to rationalize their own research challenges, Dr Akasaki persevered for 16 years, focusing on rigorous experimental design. He says that 'Once an objective has been set, a true leader should not waver in the pursuit of it'. As many other researchers abandoned work on gallium nitride, Dr Akasaki persevered, stating that he felt as if he was 'exploring the wilderness alone'. When I asked Dr Akasaki how and when an applied scientist should consider abandoning a research path that seems unlikely to bear fruit, he remained resolute that, for him, quitting was simply not an option!

Drs Peter and Rosemary Grant were awarded the Kyoto Prize in Basic Sciences for their research of evolution in Darwin's Finches. While the subjects of their experiments and the environment in which they performed their study were significant enablers, a more significant element was the circumstances that enabled them to work together, combined with excellent experimental design. The repeatedly lengthy excursions required remote field studies, over the course of nearly 40 years, presents a significant challenge to maintaining relationships with one's spouse and with one's children. Just as the Kyoto Prize includes cultural and spiritual achievement, a researcher cannot live by science alone. By traveling together, and being accompanied by their children on their extended research treks (which would have been legally impossible at the time, due to school attendance requirements, had they remained in their native United Kingdom rather living in the United States and Canada), the Grants were able to maintain complementary research tracks. Echoing Pasteur's statement that chance favors the prepared mind, the Grants maintain that observational studies must be designed to collect diverse data and focus on long-term objectives. This philosophy enabled them to witness two extreme events that produced some of their most profound observations: the most extreme El Niño condition of the past 400 years, which produced rain for 8 months; and, second, a drought in which no rain fell for an entire season. One cannot plan for or predict these events; they must simply hope to be present and prepared when they occur. Thus, the combination of excellent experimental design – being prepared for chance – and the ability to continue their remote research over many years – increasing the odds of being present to make novel observations – were significant drivers to the discoveries of these two basic scientists.

Maestro Pierre Boulez was awarded the Kyoto Prize in Arts and Philosophy as 'A Musician Who Has Consistently Set Trends through His Composition, Conducting, Writing, and Organizational Operation'. Boulez is regarded as an innovative composer, contributing to the development of contemporary music through his advancements in serialism and his utilization of electroacoustic techniques. His contributions also extend beyond composition, as he has also been active as a conductor, writer and organizer. A core philosophy espoused by Boulez is to embrace change. He says, 'the unexpected can occur anytime. Freedom of invention knows it can always rely on instantaneous resources'. He expands this philosophy beyond music into politics: 'Weak civilizations like to take refuge in the past, which makes them feel like a civilization at its best … . Powerful civilizations can take the liberty to destroy what is around them because they will immediately be able to rebuild … . The strong civilization can compare itself to the Phoenix perishing at its own stake, only to rise again'. Unlike an applied technologist such as Dr Akasaki, or basic scientists such as the Grants, an artist like Boulez cannot aim for a predetermined target, or design an observational scheme in which to witness change. An artist must create change. Boulez summarizes his philosophy with a single word: *transgression*. He explains that 'to transgress is to test the limits of our instrumental technology: the construction of an instrument and its use. To transgress is to go toward a new world – if not entirely new, at least uncommon'.

  1462-8732 **Journal of Commercial Biotechnology** Vol. 16, 2, 95–97

These cases provide interesting insights into the enablers of outstanding innovations. Technologist Isamu Akasaki succeeded through unwavering pursuit of a defined objective that many others had abandoned; basic scientists Peter and Rosemary Grant succeeded through long-term support of well-designed observational studies under conditions that few others would have been able to endure. Artist and Philosopher Pierre Boulez succeeded through the dogged pursuit of change and transgression.

These observations reveal an uncomfortable conclusion for those striving to innovate: each of the Kyoto Prize Laureates succeeded by willingly choosing a path of extreme difficulty, and never giving up. None of these paths to innovation seem terribly appealing. How many researchers (or financiers and research managers) are willing to sustain multi-decade endeavors, in the pursuit of seemingly impossible or unknown outcomes? How many people can sustain the dogged pursuit of change described by Maestro Boulez? Perhaps an acceptable compromise is that not everyone can be, or should be, an exemplary innovator. Ultimately, for the advances of these innovators to spread beyond their domains, the supportive efforts of many others – who may excel in other areas – are required. An interesting follow-up to this brief report would be to study the processes that enabled the extension of the laureates' works to the point that the laureates could be recognized for their vital early contributions. Just as the laureates likely have peers who are similarly bright, diligent and lucky but who have not produced the same significant innovations, there are likely other individuals who have played vital roles in laying foundations for great innovations that remain to be realized.[2]

NOTES

1 This study was made possible by a fellowship from Point Loma Nazarene University.

2 An even-further investigation is suggested in a quote from the late evolutionary biologist Steven Jay Gould: 'I am somehow less interested in the weight and convolutions of Einstein's brain than in the near certainty that people of equal talent have lived and died in cotton fields and sweatshops'.

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