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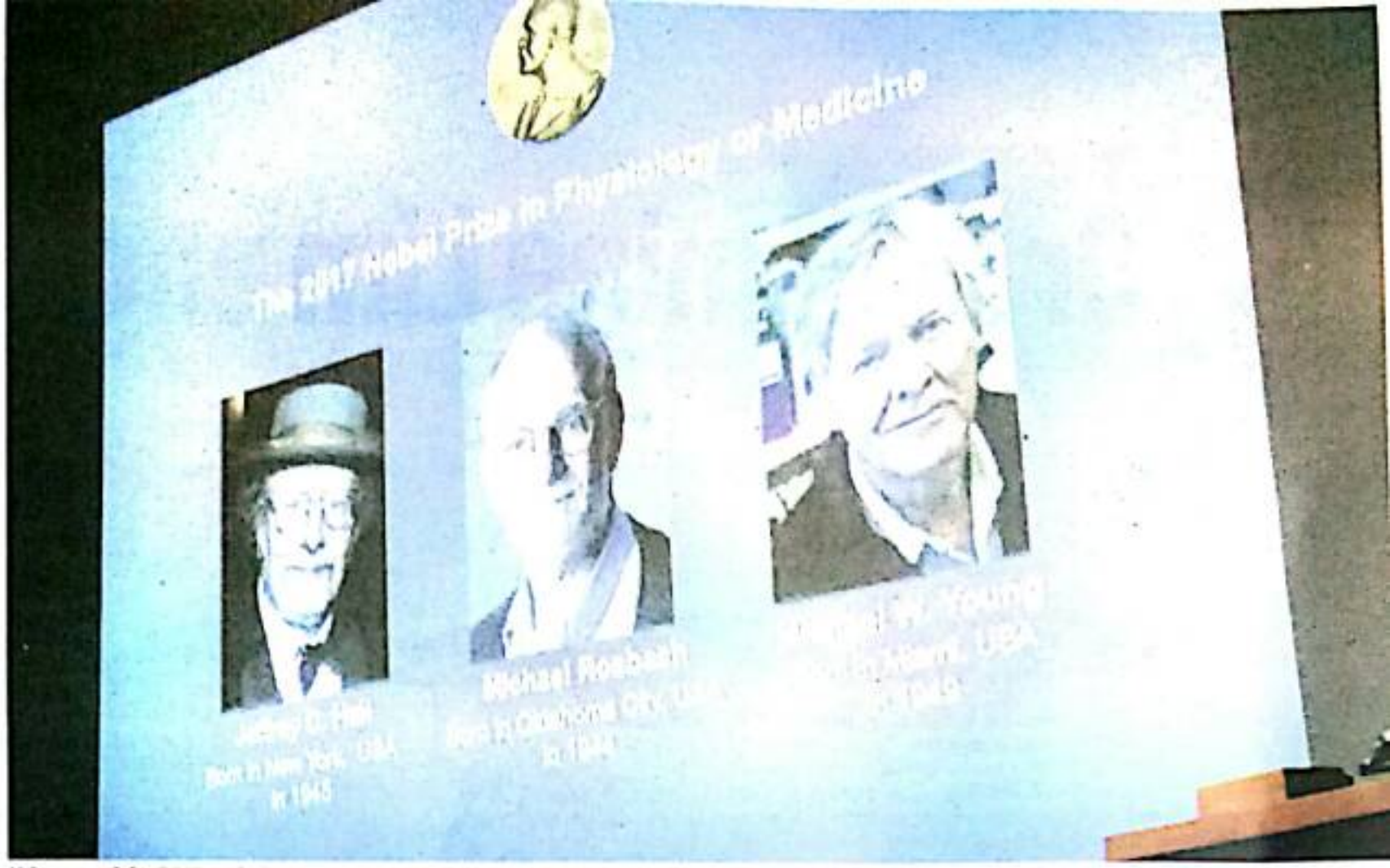

Winners of the 2017 Nobel Prize in Physiology or Medicine. (From left) Jeffrey Hall, Michael Rosbash and Michael Young are pictured on a display during a press conference at the Karolinska Institute in Stockholm on October 2, 2017. AFP

PERSPECTIVE

Evolutionary versus revolutionary research

IN the context of science and technology, a revolution can be defined as a complete or marked change in knowledge or practices. This knowledge or practices is a paradigm that shifts with a revolution in the field. The 20th century American physicist and science historian Thomas Kuhn, in his book *The Structure of Scientific Revolutions*, wrote that paradigm is the vehicle for scientific theory — it provides a map of knowledge elucidated by scientific research. He argued that, due to the complexity of nature, it cannot be explored randomly thus making such a map an essential tool for the development of science.

A scientific revolution will result in a paradigm shift that provides a new or perhaps highly revised map of the knowledge as it is currently understood. In the month of October, we celebrated the many paradigm shifts and scientific revolutions by way of the Nobel Prizes. For many scientists, this can be a time of reflection — what have we achieved, how revolutionary has our contributions been, have we shifted any paradigms while celebrating the brilliance, courage and tenacity of the laureates for persevering and achieving the success in their work.

While I do not have the in depth analysis or statistics for all the Nobel prizes awarded, I hazard an assumption that they were mostly, if not all, given out for discoveries that were a result of revolutionary research which led to paradigm shifts in knowledge. This is perhaps where I should elaborate further on evolutionary versus revolutionary research. This difference is what many researchers (including myself) and policy makers struggle to define and balance. In my opinion, you cannot have one without the other.

I would like to define evolutionary research (not to be confused with evolutionary biology research) as increments to the core paradigm that was first put in place as a result of revolutionary research.

Let me discuss some examples. Many of us have heard of a molecule called DNA. This is basically the genetic building blocks for life. Humans had been aware of the concept of genetics and heredity for at least a few hundred years, if not more, before we knew what these molecules were and how they worked.

While the concept of heredity may have been understood — ie parents passing on traits to their offspring — the vehicle that was passing on these traits was unknown. In fact, Friedrich Miescher who is credited for first isolating DNA, had no idea what its function was, although he did at a later point raise the possibility that this thing called nuclein (as he had named DNA back then), may actually be associated with heredity.

In 1953, Francis Crick and James Watson were able to figure out what the DNA molecule looked like. In being able to 'see' the structure of DNA, they were able to propose how DNA was able to function as a record and carrier of genetic information. Solving the structure of DNA resulted in a paradigm shift as to how we understand heredity. For the discovery of DNA's molecular structure, Watson, Crick and Maurice Wilkins were awarded the Nobel prize in 1962.

This scientific revolution heralded in the field of what we now know as molecular biology. Many of us may feel distant from molecular biology — perhaps an academic field of study far removed from our daily existence. On the contrary, molecular biology affects us in many ways that we may not realise. Molecular biology is the science behind much of what we know as modern biotechnology. It is actually all around us — from how we understand, diagnose and treat diseases, how we produce food to how we treat wastes and clean water supplies. Even doing our laundry may have influences from molecular biology.

The 2017 Nobel Prize in Physiology or Medicine were awarded to three biologists — Jeffrey Hall, Michael Rosbash and Michael Young for their work in trying to understand the molecular workings of the circadian rhythm, in other words, understanding how our bodies keep time to allow for sleep and awake cycles.

To enable their discoveries, they utilised existing knowledge in molecular biology that in turn enabled new knowledge to be discovered. In a way, their work was evolutionary research that is revolutionary. They were able to show that our sleep cycles are regulated biologically at the molecular level.

Today, there are many examples of how evolutionary research have led to revolutions. The smartphone had been around in the 2000s prior to 2007. But it was Apple's iPhone, first introduced by Steve Jobs 10 years ago, that revolutionised the way we use smartphones and made them the almost ubiquitous appendages we all seem to have on our persons nowadays. Again evolutionary research was able to be revolutionary.

As a species, we have been sending rockets into space for six decades (October 4, 1957 is the anniversary of the first artificial satellite launched into orbit — Sputnik by the then USSR). And for six decades, we had been doing it the same way — using rockets to break free of the Earth's gravity, that were then discarded when their fuel was expended. This changed only in 2017 when SpaceX, the company founded by billionaire serial entrepreneur Elon Musk, was able to rewrite how rockets can be used, or rather reused, by recovering and re-launching a recovered rocket. Again, an example of evolving something already in practice to be revolutionary.

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These diverse examples demonstrate how research should be revolutionary to enable knowledge discovery and create paradigm shifts. At the same time, evolutionary research is necessary to build on the existing paradigm and build up capacity. The critical mass in knowledge and technical ability will allow for further revolutions. However, to cross the threshold from evolution to revolution, major paradigms must be shifted, including paradigms regarding how we fund and support research programmes.

I believe innovation can thrive anywhere provided the right environment. It is such an environment that we as a nation must strive to create. Innovation should not be limited to what we perceive to be useful applications by following the crowd, buzz-words and trends. The future is not ours to see, thus policy makers and funding agencies must rely on the intentions of the research carried out to evolve and/or lead to revolution. Instead, we must allow the intellectual freedom for the creators and makers of tomorrow to explore, evolve and lead our society to the revolutions and paradigms of the future.

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