What Role Do the Public and Private Sectors Play in Pharmaceutical Innovation?

by Yanick Labrie

The discovery and marketing of countless therapeutic drugs and vaccines over the past century has undeniably helped to revolutionize the field of health care. Despite the scope of this progress and the benefits that have flowed from it, the pharmaceutical sector continues to be the target of numerous criticisms. Some people think that new drugs are not discovered by the industry, but are instead the result of work done by university researchers financed primarily with public funds. According to this story, pharmaceutical companies simply amass profits by exploiting the work carried out upstream by these scientists without making any real contribution.

The Process of Drug Discovery and Development

In the early stages of the process of discovering and developing a new medication, the basic research carried out in public research centres and universities does indeed play a crucial role. In the vast majority of cases, however, it is not university researchers who discover new drugs. For example, barely 9% of new drugs approved by the Food and Drug Administration (FDA) in the U.S. between 1990 and 2007 were discovered by public sector research institutions. University researchers focus instead on generating new knowledge that leads to a better understanding of the factors responsible for a disease or health condition.

Once the underlying causes of a disease have been highlighted, researchers attempt to discover a biological target for a new potential drug, most often a gene or protein. So begins the whole applied research aspect that leads to the discovery of a molecule capable of curing or preventing the disease. Thousands of molecules are tested in order to determine which ones have the characteristics required to become a potential medication. From this point on, it is primarily private biotech firms and large pharmaceutical companies that fund or carry out this work.

Once a promising molecule is discovered, pharmaceutical companies proceed to preclinical and clinical trials during which they try to determine the safety of the drug being studied, its mechanisms of action, its toxicity, its possible side effects, etc. Clinical trials are generally divided into three phases and can be spread out over a period of six or seven years.

These clinical trials, which in the United States are over 90% financed by private biopharmaceutical companies, account for over half of the cost of developing a drug and take place in a context of very strict oversight and regulation. The percentage...
of attrition at this stage is very high: A very large majority of molecules do not successfully make it past the hurdle of clinical trials, and end up being abandoned. According to researchers at the U.S. Congressional Budget Office, only 8% of new molecules studied that reach the clinical trial stage are approved for commercialization.7

The final stage of this long process consists in obtaining authorization from regulatory bodies for the commercialization of the drug. According to a recent study, it takes on average around one year for a drug to obtain such approval. From 2001 to 2010, the median wait was 322 days in the United States, 366 days in Europe and 393 days in Canada.8 Obviously, it is once again private sector companies that bear the costs related to approval requests.

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The development of a drug is a long and costly process. All told, pharmaceutical companies must devote an average of 12 to 15 years of research and $1.2 billion of investments9 to go from the discovery of a promising molecule to the commercialization of a medication from which patients will benefit (see Table 1).

It is also a risky process, because only two out of ten drugs that do make it to market generate sufficient sales revenue to cover average R&D costs.11 As a result, 20% of the drugs marketed have to generate sufficiently high profits to cover the revenue shortfalls of the other 80%.

#### The Respective Contributions of the Public and Private Sectors

Several analyses have been carried out in recent years regarding the respective sizes of the contributions of the private and public sectors in the discovery and development of therapeutic drugs. In 2001, the U.S. Congress gave the National Institutes of Health (NIH) the mandate of preparing a report on the origins of the bestselling drugs, namely those with sales exceeding $500 million a year. Of the 47 drugs included in the sample, the study revealed that only four had been discovered and developed primarily with the use of public funds.12

More recently, economists from Tufts University in Massachusetts traced the history of the development of the 35 most important drugs and drug classes. While the public sector plays a prominent role in basic research, the private sector was nonetheless responsible for major advances in basic science in 20% of these drug classes. Moreover, it deserves credit for major progress in applied science in 97% of the drug classes, and in 80% of them when it comes to improvements in the clinical applications of drugs or their manufacturing protocols.13

Drugs belonging to the class of beta blockers, used to treat various cardiovascular diseases, are a clear example of the importance of the role of the private sector in pharmaceutical innovation. After some major breakthroughs in the field of cell biology at the University of Georgia in the 1940s, R&D efforts were pursued for a number of years in private sector companies, in particular at Imperial Chemical Industries (now part of AstraZeneca) and at Eli Lilly. This extensive work culminated in the creation of a new therapeutic class starting in the early 1960s. The research carried out by the pharmaceutical industry in the 1980s and 1990s then led to the development of improved beta blockers.
allowing a whole range of diseases, including cardiac arrhythmia, glaucoma and hypertension, to be treated more effectively.\textsuperscript{14}

Another example is the discovery of therapeutic drugs belonging to the class of statins, which have allowed many patients to lower their cholesterol levels and have contributed to a substantial drop in mortality rates due to cardiovascular disease.\textsuperscript{15} It is in the 1950s that the first studies appeared establishing a link between cholesterol and the risks of cardiovascular disease. Statins, however, were only discovered in the mid-1970s following a number of years of research carried out in the laboratories of the Sankyo pharmaceutical company by a group of researchers led by Japanese microbiologist Akira Endo. Following the conclusion of the subsequent development process by the companies Sankyo and Merck, the first therapeutic drug belonging to the class of statins finally made it to market in 1987.\textsuperscript{16}

Indeed, a substantial proportion of drugs would not have seen the light of day if not for the contribution of the pharmaceutical industry. Pharmaceutical companies remain the only players ready to invest the considerable sums required to discover and develop drugs and to take on the risks associated with those investments. In the United States, 60\% of funding for biomedical research comes from private pharmaceutical and biotech companies.\textsuperscript{17}

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In Canada, the public funds devoted to biomedical research through the Canadian Institutes of Health Research (CIHR) amounted to $584 million in 2012-2013. Other government agencies like Genome Canada, the Canada Foundation for Innovation, the Canada Research Chairs and the Natural Sciences and Engineering Research Council of Canada also devote a few hundred million dollars a year to health care R&D.\textsuperscript{18} The big pharmaceutical companies, for their part, invested over $1 billion in R&D in Canada in 2013.\textsuperscript{19}

\textbf{Is the Pharmaceutical Industry Less Innovative?}

Since the mid-1990s, the number of new drugs approved each year by the regulatory authorities has been trending downward, both for Health Canada and for the FDA in the United States. This has led several people to conclude that the pharmaceutical industry was losing its dynamism in terms of innovation.\textsuperscript{20}

If we look back further in time, however, we see that there has been a significant upward trend in the number of drugs approved in the United States since the 1970s. It is the exceptionally high number of drugs approved in 1996 that give the impression of a decline during the subsequent period (see Figure 1). This year is an anomaly, explained by the FDA catching up on its pending evaluations after having fallen behind and built up a backlog.\textsuperscript{21}

Furthermore, the method of simply counting the number of new approvals is of limited use for measuring the actual innovative character of new drugs.\textsuperscript{22} Indeed, although each molecule is a distinct chemical compound, some of them have more significant therapeutic properties than others. When this factor is taken into account, it becomes clear that the percentage of approved drugs that are considered the most innovative, known as “first-in-class” drugs, has been growing since the early 2000s.\textsuperscript{23} It is also recognized that today’s drugs are generally more effective and better

\textbf{Figure 1 — Number of drugs approved annually by the Food and Drug Administration in the United States, 1970-2013}

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Conclusion

The discovery and development of new drugs are the result of a close collaboration between university and industry researchers. In this process, the public and private sectors pursue distinct but complementary objectives. Whereas the role of the public sector is centred on deepening our basic understanding of disease, that of the private sector is more focused on applied research aimed at converting this knowledge into effective treatments. The benefits that flow from public subsidies to university research can be reaped only once effective treatments have been developed. Only the pharmaceutical industry is in a position to play this role.

References

1. The present Economic Note is the second in a series dealing with the issue of pharmaceutical innovation. For a brief survey of the scope of the progress achieved in this regard over the past 100 years, see Yanick Labrie, “How Pharmaceutical Innovation Has Revolutionized Health Care,” Economic Note, Montreal Economic Institute, June 2014.

2. See for example Mariana Mazzucato, “Pfizer’s bid for AstraZeneca shows that big pharma is as rotten as the banks,” The Guardian, May 11, 2014.

3. It should be noted that an increasing number of partnership agreements are being signed between university researchers and pharmaceutical companies to facilitate the discovery of new molecules. See among others Nathalie Vallerand, “Des PPP pour faciliter la recherche,” Les Affaires, March 1st, 2014, p. 34; Daniel X. Yang and Yunsoo A. Kim, “Helping Science and Drug Development to Succeed through Pharma-Academia Partnerships,” Yale Journal of Biology and Medicine, Vol. 86, 2013, pp. 429-432.


18. See Canadian Institutes of Health Research, Canadian Institutes of Health Research Annual Report 2012-13, June 25, 2013, p. 2, as well as the annual reports of the agencies cited. For various reasons, the available data do not allow us to sketch a more accurate picture of public funding in Canada. CHIR does not indicate any research theme for subsidies totalling $200 million. A portion of the funding of public agencies comes from private foundations. Furthermore, biomedical research includes fields other than pharmaceutical research.


22. Ibid., pp. 5-7.
