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IP International Journal of Comprehensive and Advanced Pharmacology

Journal homepage: <https://www.ijcap.in/>

Review Article

Bioentrepreneurship: A venture for commercializing biotechnological knowledge

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ARTICLE INFO

Article history:

Received 18-06-2021

Accepted 14-07-2021

Available online 05-08-2021

Keywords:

Bioentrepreneurship

Biotechnology

Regional level research

Firm level research

ABSTRACT

The term "biotechnology" is widely used and encompasses many different technologies. Consulting firms provide common definitions of modern biotechnology. The term "modern biotechnology" refers to all innovative methods, processes or products, including the use of living organisms or their cellular compartments, and the use of biochemistry, molecular biology, immunology, virology, microbiology, cell biology or environmental sciences and engineering. Biotechnology and entrepreneurship are intrinsically linked together, and are studied biotechnology at the regional, firm, and individual level of analysis. The concept of "bioentrepreneurship", is described as a wealth created by applying the life sciences to a business environment. Bioentrepreneurs seek business value in the technologies they use to conduct biotechnology research. Some well-known bio startups are based on multiple companies. Biotechnology and entrepreneurship are essentially linked. In recent years, a large number of articles in the business literature have studied biotechnology at the level of analysis of regions, companies and individuals. This review article will encourage stakeholders to address the research space which have been recognized and will help more progress in this captivating area of interest in the field of biotechnology and entrepreneurship.

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1. Introduction

In the current years, entire world is in the surge of innovation. Everyday new ideas lead to the development and reformation of any material which can be natural or synthetic. Biotechnology is one of those areas where wave of new ideas brought several products of agricultural, environmental, medical and pharmaceutical applications.

2. Definitions and Concepts

2.1. Biotechnology

The term "Biotechnology" was first used by "Karl Ereky" in 1919, meaning the production of products from raw materials with the aid of living organisms.¹The era of biotechnology-enhanced agriculture began in the 1990s with government approval for commercial deployment of biotech soybeans, corn, cotton, canola, and papaya. Because of their tremendous production advantages, biotech crops have become the most rapidly adopted technology in the history of agriculture.

The word "biotechnology" is extensively applied and covers a number of different technologies. A commonly used definition of modern biotechnology is provided by the

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consulting company Ernst and Young in 2000. Ernst and Young were the first to regularly publish detailed reports on the biotechnology industry, starting in 1986 for the sector in the US and, later, also covering Europe, Asia, and some specific countries (e.g., UK, Germany).

Therefore, Ernst and Young's definition of biotechnology is widely accepted by both practitioners and academics: "The term "modern biotechnology" refers to all the innovative methods, processes, or products, which include the use of living organisms or their cellular compartments and draw on the results and knowledge generated from research in the fields of biochemistry, molecular biology, immunology, virology, microbiology, cell biology, or environmental and engineering sciences."²

Since decades the biotechnology has gratified our lives in all the aspects. But mankind is swept with the concept of biotechnology from the time when the human civilization was aware of fermentation products. Fermentation was a powerful tool to improve the human lives in the ancient times. Yeast is used since then to prepare bread, various fermentation products and to produce vinegar, alcoholic beverages like whiskey, wine, beer, etc.

Thus, before 17th century biotechnology was all about preparation of cheese, fermentation and crossbreeding of animals; whereas after 17th century till 19th century the biotechnological concepts included plant and animal tissue culturing, genetic modifications, development of vaccines and antibiotics; and after the 19th century the concept of molecular biology, coding and de-coding the genetic characters, concept of cytoplasmic hybridization and first ever monoclonal antibodies, has revolutionized the diagnostics. The development in biotechnology sector is very fast. Entrepreneurship and innovation are the major factors in all stages in the development of any sector.³ In the late 20th and early 21st centuries, biotechnology has expanded to include new and diverse sciences, such as genomics, recombinant gene techniques, applied immunology, and development of pharmaceutical therapies and diagnostic tests.

Today's entrepreneur is not only the innovator but also the developer of ideas and at the same time grabs the opportunities and encases it into marketable entities. The entrepreneur have to be a team leader and also have to look after the financial and material resources required for all innovative ideas to be made available for the consumers.⁴ Few of such entrepreneurs are bringing up market of biotechnology and biotechnological products by setting up the trends in Bioentrepreneurship.

2.2. Bioentrepreneurship

Bioentrepreneurship also referred as BioE or science entrepreneurship or bioscience enterprise, life science entrepreneurship, entrepreneurship in biotechnology or biotechnology enterprise. It is the entrepreneurship of

biosciences which acts as a bridge of innovation connecting academia to industry. It is the business of utilizing ideas and innovations of biological sciences and products obtained thereof to gain profit and serve the society.⁵ The concept of "bioentrepreneurship" was introduced by Persidis in 1996, who described bioentrepreneurship as the wealth creation derived from the application of the biosciences to the business context. Bioentrepreneurs look for commercial value in the technologies that they apply in conducting research in the field of biotechnology.⁶ Biotechnology entrepreneurship is thus the sum of all activities necessary to build an enterprise through the melding of both scientific and business disciplines. It utilizes biological processes for industrial and other purposes, especially the genetic manipulation of microorganisms for the production of antibiotics, hormones, etc.⁷ A biotechnology company therefore will require a strategic alliance with a large pharmaceutical company to take the product to market.⁸

The mid-1970s emergence of technologies based on recombinant DNA and monoclonal antibody technologies, which evolved from the revolutionary work of scientific partnerships such as that of Cohen and Boyer, and Kohler and Milstein, established the foundations for the biotechnology industry. At present India is among the world's top biotech powers. However the concept of "bioentrepreneurship" is fairly new in India. Scientist in our country still follows the traditional research culture, they have not completely moved out from their safe zone yet.

Although the need for academic excellence is understandable, but right now the need of the hour is to provide safe, affordable healthcare solutions that can be used to save millions of lives. This is the major work on the shoulders of the bioentrepreneurs today. Every bioentrepreneur should try to find a market for his research; while he is working on a basic research he must develop products of commercial value. Every bioentrepreneurs must thoroughly understand the grassroots of biotechnology sector such as research, collaboration, infrastructure, and technology and commercialization capital and come up with an alternative business model to achieve success. Some prominent bioentrepreneurship based companies are;

1. Abbott Diagnostics Division
2. AbbVie Biotech Company
3. Amgen Inc.
4. Amyris Inc.
5. Antiverse: It focuses on making new antibodies in-silico by utilizing various computing software and processes.
6. Aventis Pharma
7. Bharat Serums
8. Biocon
9. Cambrian Genomics : It focuses on laser printing DNA,
10. Canon U.S. Life Sciences, Inc.

11. Chiron Behring Vaccines
12. Genentech Inc.
13. Genome Compiler: It provides a software platform for the manipulation of genomes and genetic engineering.
14. Gilead Biotech Company
15. Lonza Biologics Inc
16. Mahyco Monsanto
17. MaterializeX: It is a biotech company, focuses on making new chemicals and compounds by combining chemistry and data science. They are also trying to improve current industrial processes.
18. Neurotech Inc.
19. Novo Nordisk
20. Novozymes North America Inc.
21. Panacea Biotech
22. Rasi Seeds
23. Santa Cruz Biotechnology Inc
24. Serum Institute of India
25. Syros Pharmaceuticals
26. Venkateshwara Hatcheries
27. XBiotech

2.3. Pillars of bioentrepreneurship

Biotechnology is one of the strongest growing industries of the twenty first century. Yet, the sector is still young and many biotechnology firms are at an early stage of their life cycle. Thus, biotechnology and entrepreneurship are intrinsically linked together, and over the last years a substantial number of articles in the entrepreneurship literature have studied biotechnology at the regional, firm, and individual level of analysis.

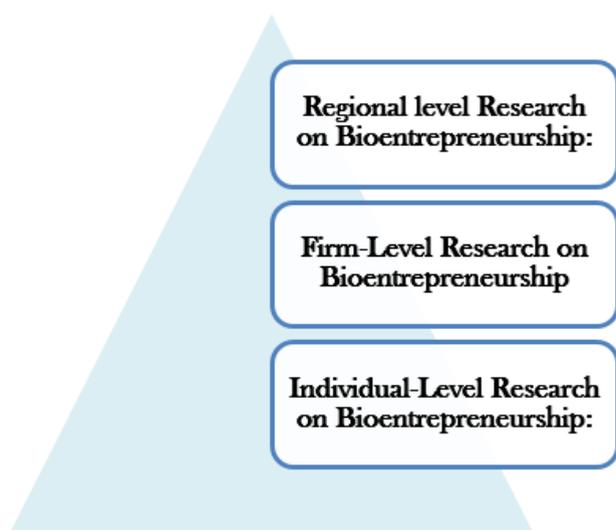


Fig. 1: Pillars of Bioentrepreneurship

2.4. Regional level research on bioentrepreneurship

Biotechnology research at the regional level has primarily focused on innovation networks covering biotechnology firms and other organizations, and on the development of regional biotechnology clusters. Innovation networks refer to links (alliances) between stakeholders that participate in the biotechnology innovation process and share resources and activities. Specifically, stakeholders of biotechnology networks include dedicated biotechnology firms, large incumbent firms, and public research institutions/universities. The emergence of biotechnology networks and the effects of these networks on the firms involved have been studied by a substantial number of scholars from different disciplines e.g., management, sociology, industrial organization, etc.

2.5. Firm-level research on bioentrepreneurship

While research at the regional level is substantial, certainly most of the research on biotechnology entrepreneurship has been conducted at the firm level. At this level, research has investigated strategies and business models of biotechnology firms, strategic alliances these firms form, and mergers and acquisitions between firms. The pattern of inter-firm collaboration in biotechnology is probably more extensive than in any other industry.^{9–12} In addition to that, the biotechnology industry is characterized by a social network structure requiring a shift from coordinating the internal activities of the firm through a traditional command and control structure to providing organizational support for internal and external exchanges. In what follows we review research on (i) strategies and business models, (ii) strategic alliances, and (iii) mergers and acquisitions of biotechnology firms.

2.6. Individual-level research on bioentrepreneurship

Biotechnology research at the level of the individual is still sparse. This fact is surprising given the general focus on the individual in entrepreneurship research and because practitioners emphasize that biotechnology entrepreneurs are somewhat different from the general population of entrepreneurs because they need to possess both industry and managerial knowledge on the one hand, but also scientific knowledge about new biotechnological development on the other hand.^{13,14} The few existing individual-level studies have either focused on biotechnology scientists, individual biotechnology managers, or the biotechnology venture's top management team.

The study shows that more new biotechnology firms are founded in regions where more researchers/ scientists work at universities and research institutes. From the perspective of the knowledge seeker, a survey of 507 biomedical researchers revealed that scientific competition, costs of

providing the knowledge, and knowledge suppliers' past engagement in commercial activities counteract information sharing.¹⁵ Further, although the overall connectedness between academic scientists and firm inventors within the scientific community is substantial, the transfer of knowledge appears to be dependent on the existence of “gatekeepers” — individuals who occupy prominent positions in scientific and technological networks.¹⁶

Finally, another important distinction between biotechnology firms refers to the business models they pursue. First, product-oriented firms develop and commercialize new biotechnological products such as therapeutics and diagnostics (red biotechnology), transgenic plants (green biotechnology), or enzymes (white biotechnology). Second, service firms use an innovative biotechnology to offer its application to other companies as a research service. As compared to product firms, service firms generate revenues much earlier in their life cycle and sometimes grow without or with only minor outside investment. Third, some biotechnology firms use their proprietary technology for both internal new product development and offering its application as a research service to others (“hybrid companies”).¹⁷

Although founding and managing a biotechnology firm is among the most complex entrepreneurial endeavors due to the competitiveness and dynamism of the environment and the technological complexity, there is little research how strategic decisions are made within biotechnology firms. Taken together, research at the individual and team level has demonstrated that highly competent (star) scientists are often the trigger of commercializing a new biotechnological technique by founding a new venture. Further, it appears that the CEO is a central person for the success of biotechnology firms, and that the composition and competencies of the firm's top management team play an important role in explaining biotechnology ventures' development trajectories and, finally, performance. Finally, one issue that has basically remained untouched in the field of biotechnology entrepreneurship is studies covering multiple levels of analysis and investigating cross-level effects. Indeed, scholars have claimed that there is a general lack of cross-level studies both in the field of entrepreneurship¹⁸ and organization science.¹⁹ Cross-level studies could cover interactions between regional and firm levels, firm and individual levels, and regional and individual levels.

3. Conclusion

The purpose of this review is to focus on important research streams on entrepreneurship in the context of the biotechnology industry. Author has summarized in short the studies at the regional level, firm level, and individual level of analysis. Although sufficient work has been done on bioentrepreneurship, but still ample research

opportunities for scholars to advance the understanding of bioentrepreneurship at multiple levels of analysis is needed. The stakeholders interested in the field of biotechnology entrepreneurship will get an overview of different aspects of bioentrepreneurship. This article will stimulate additional research that addresses the research gaps identified and contributes to further advancing this fascinating field of interested in the field of biotechnology entrepreneurship..

4. Conflict of Interest

The authors declare that there are no conflicts of interest in this paper.

5. Source of Funding

None.

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Cite this article: Gurunani SG, Mangrulkar SV, Jawal DT, Chaple DR. Bioentrepreneurship: A venture for commercializing biotechnological knowledge. *IP Int J Comprehensive Adv Pharmacol* 2021;6(2):48-52.