Rapid response through the entrepreneurial capabilities of academic scientists

Academic scientists who develop entrepreneurial capabilities can make strategic, path dependent decisions that enable university spin-offs to rapidly respond to global crises.

Andrew Park, Azadeh Goudarzi, Pegah Yaghmaie, Varkey Jon Thomas and Elicia Maine

Academic scientists play a central role in the production and translation of breakthrough scientific inventions through the formation of university spin-offs[1–3]. Well-endowed science-based ventures, attracting resources and advancing novel capabilities, can rapidly respond to pressing global health and humanitarian crises such as COVID-19[4]. Policymakers are highly motivated to leverage university science for the dual purpose of solving emerging challenges and increasing economic productivity[4–9]. Yet scholars suggest that, despite increasing investment by the United States government in university research, innovation ecosystem growth is lower today than it has been in the previous four decades[10,11].

Using evidence from the University of British Columbia (UBC) nanomedicine spin-off AbCellera Biologics Inc. (AbCellera), which was the first to co-develop an antibody therapeutic for COVID-19, we examine the capabilities enabling an academic scientist–entrepreneur to respond rapidly to health and humanitarian crises and create economic and social impact. We argue that well-endowed university spin-offs can leverage and extend entrepreneurial capabilities for rapid pandemic response. Leveraging pre-formation entrepreneurial capabilities, AbCellera rapidly identified and co-developed a targeted antibody in partnership with Eli Lilly. Academic scientist co-founder and CEO of AbCellera, Carl Hansen, notes:

"When we first mobilized against COVID-19 in March of last year, we made a decision to develop a single antibody, emphasizing speed and scalability so that we could help as many patients as possible, as quickly as possible. That antibody, bamlanivimab (LY-CoV555), was the first to receive FDA Emergency Use Authorization and has treated more patients than any other neutralizing antibody — preventing more than 22,000 hospitalizations and 11,000 deaths in the US alone[12]."

Entrepreneurial capabilities and path-dependent decisions

Recent research[4] suggests that there are four pre-formation entrepreneurial capabilities that lead to well-endowed university spin-offs. This research is rooted in dynamic capabilities theory[13], which posits that some firms exhibit heightened performance due to their ability to leverage unique sensing and shaping and seizing capabilities. Subsequent literature has extended this theory to the level of the individual entrepreneur[14], and more specifically, scientist–entrepreneurs who form university spin-offs[4]. Academic scientists have underappreciated agency to shape commercialization opportunities, particularly in the years prior to venture formation[15,16]. Early path dependent decisions made by scientist–entrepreneurs are critical to post-formation firm success[4], for example, through sensing and shaping capabilities such as technology-market matching[17,18] and seizing capabilities such as claiming and protecting the invention, attracting and mentoring the founding team, and strategic timing of firm-formation[2,19,20]. While empirical research related to dynamic capabilities theory has largely focused on firms post-formation, we demonstrate, through an extended case study, that path-dependent, pre-formation decisions taken by scientist–entrepreneurs have significant influence on rapid pandemic response through university spin-offs.

We show that these capabilities helped expand AbCellera's firm value chain so that they were able to discover the antibody bamlanivimab against the SaRS-CoV-2 virus in just 90 days, resulting in the development of an FDA emergency-use-authorized therapeutic in eight months[21]. AbCellera's benchtop technology is predicated on single-cell analysis chambers, each of which has a volume of less than one nanoliter, allowing for B cell secreted antibody detection within hours, compared to weeks, as seen in traditional antibody discovery experimentation.

As a faculty member at UBC, Hansen, his team and his collaborators developed a highly novel microfluidic technology, which forms the foundation of AbCellera's antibody discovery platform and was their entry point into the antibody therapeutic market. This microfluidic technology, along with antibody-focused research produced by his graduate students in the mid-2000s and later supported by Canadian government science grants related to antibody discovery, indicates that Hansen had already targeted the antibody market for his microfluidic technology long before AbCellera's formation in 2012, demonstrating the first entrepreneurial capability, technology-market matching. Hansen further demonstrated prioritization of the antibody market when he negotiated a "worldwide, exclusive license to the… Technology solely within the Antibody Field of Use"[22] with UBC. This early prioritization of the antibody market by Hansen enabled AbCellera to rapidly develop bamlanivimab. A timeline of the path-dependent decisions described in this section, along with other notable milestones and the demonstration of Hansen's entrepreneurial capabilities, is presented in Fig. 1.

Early patenting and high-quality research publications facilitate science commercialization through university spin-offs[2,4,23]. We find evidence of Hansen engaging in the entrepreneurial capability of claiming and protecting the invention through two relevant patents filed by Hansen and his colleagues in 2010, two years before firm formation[24,25] and ten years before they were utilized in rapidly responding to COVID-19. We also identified early papers in high quality journals, written by Hansen and his colleagues[26,27] up to seven years before firm formation (Fig. 1): these papers are evidence of the progression of AbCellera's technical capabilities. These capabilities and intellectual property signalled credibility and facilitated fundraising and partnerships, which were leveraged to develop bamlanivimab in 90 days, while traditional drug discovery and commercialization can stretch up to 20 years[28].

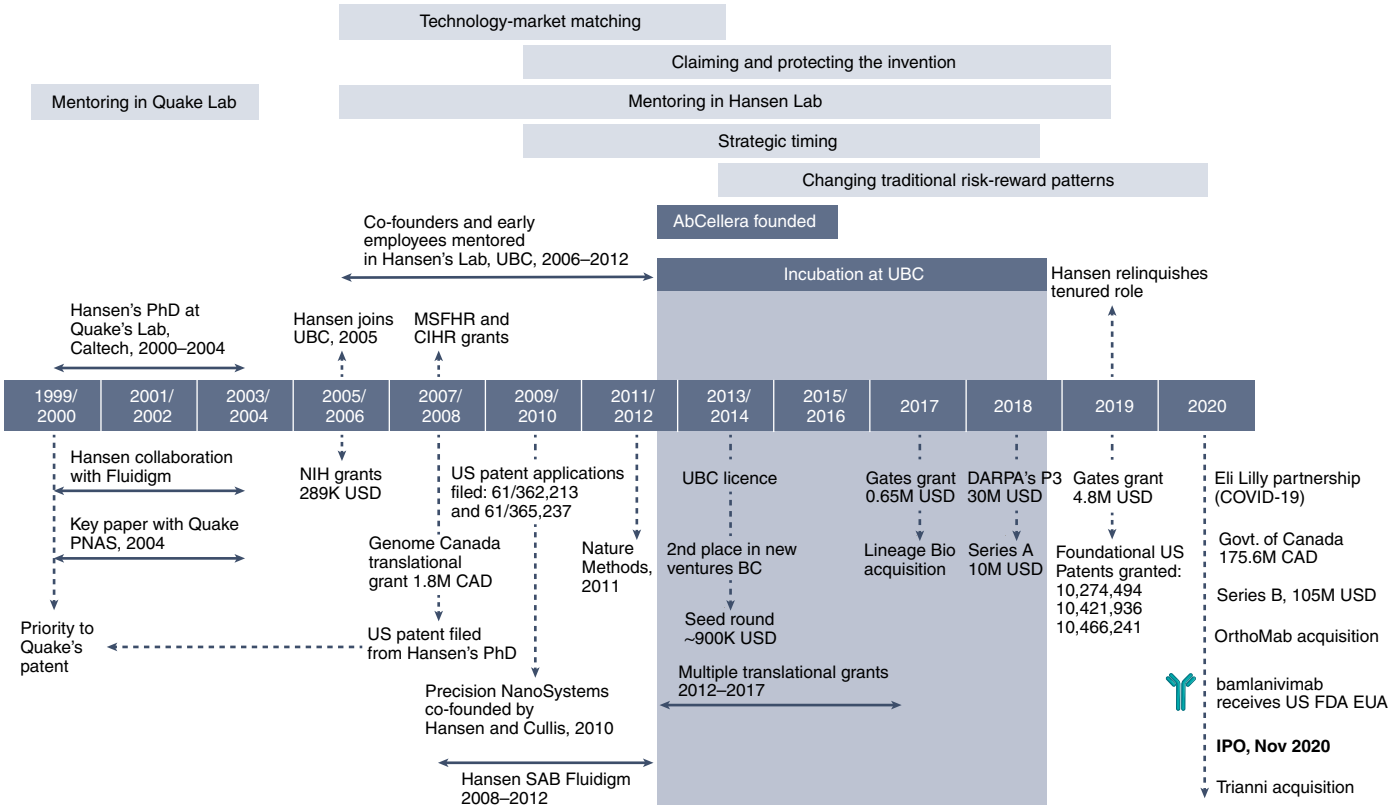

Fig. 1 | Timeline of AbCellera's milestones and demonstration of Carl Hansen's entrepreneurial capabilities. The data sources include AbCellera's (and their partners) websites and press releases, Pitchbook, LinkedIn and other social media profiles, grant information released by public funding agencies such as DARPA, NIH, Genome Canada, MSFHR, NSERC, and CIHR, patent data from the US Patent and Trademark Office and Google Patents, journal publications and United States Securities and Exchange Commission filings.

Mentoring is critical for scientist–entrepreneurs[4,29], and we find evidence of entrepreneurial mentoring both pre-formation as well as post-formation. Hansen was initially mentored by Prof. Stephen Quake (and his key collaborators at Fluidigm, who pioneered the development of microfluidics instrumentation for biological research) during his PhD at the California Institute of Technology. As a faculty member at UBC, Hansen maintained collaborative research agreements with Fluidigm. Relatedly, Lineage Biosciences' Ig-SEQ technology was co-developed by Stephen Quake, suggesting that AbCellera was familiar with the platform prior to acquiring it, de-risking the purchase. Crucially, Hansen also mentored graduate students and post-doctoral fellows from his research lab, who became co-founders and early employees of AbCellera. Former Hansen lab members Veronique Lecault, Kevin Heyries and Kathleen Lisaingo have grown into senior leadership positions at AbCellera. Such scientific and entrepreneurial mentoring allowed Hansen to leverage the existing trust among his former lab members to drive highly coordinated and fast decision-making at AbCellera, thus enabling rapid pandemic response.

Strategic timing of firm formation has been shown to play an important role in raising financing[2]. Typical venture capital investors expect to recoup their investment in three to five years, thus for science-based firms facing high uncertainty, it may be beneficial to delay firm formation to shorten the time to commercial viability, to better meet investor timelines[2,9]. Substantial evidence from Hansen's PhD thesis, patents, papers, research grants, and the research conducted by his graduate students at UBC indicates that his scientific expertise surrounding microfluidic technologies, which AbCellera utilizes for its single-cell antibody screening procedure[30], was developed prior to firm formation and supported by a significant early stage translational grant (Fig. 1). AbCellera stayed on the UBC campus for six years post-formation and Hansen maintained his UBC faculty position until 2019.

This extended incubation period allowed AbCellera to focus on its scientific development, incurring significantly lower costs, both in operating overhead and in onboarding a highly skilled workforce, and providing better access to complementary research and technologies from other labs. Hansen's previous experience co-founding Precision Nanosystems with serial scientist–entrepreneur Pieter Cullis also influenced AbCellera's early decision-making, incubation, and commercialization success.

As a result, Hansen didn't need to source his first external seed investment until late 2014 (ref. [31]) and was able to delay Series A financing until 2018, when a strong case for commercial viability and multiple rounds of financing had been built. AbCellera received several rounds of Defense Advanced Research Projects Agency (DARPA) funding during that incubation period, most notably a 30M USD award from DARPA's Pandemic Prevention Platform (P3) program in 2018, which specifically molded the firm's capabilities in rapid antibody discovery. The expansion of AbCellera's capabilities spurred several more significant financing events, including a 175.6M CAD investment from the Government of Canada in May 2020, a

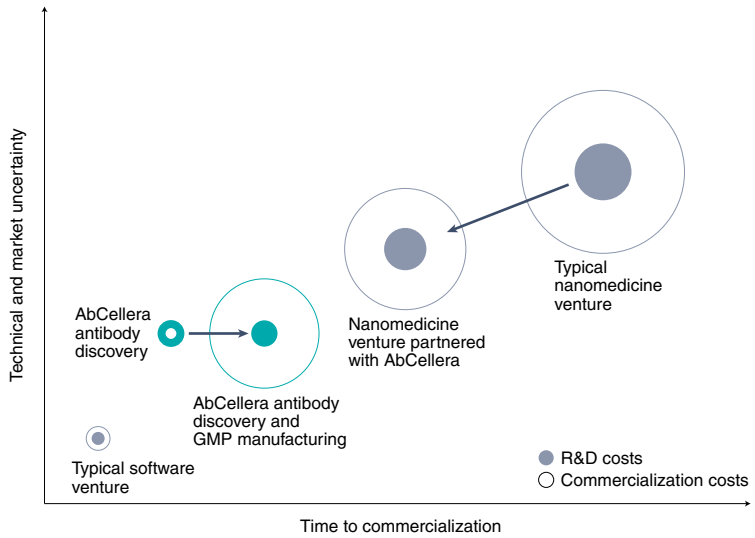

Fig. 2 | A comparison of relative R&D and commercialization costs and level of technical and market uncertainty facing typical software and nanomedicine ventures. Included are separate bubbles denoting AbCellera's antibody discovery platform and AbCellera's envisaged end-to-end antibody discovery and manufacturing platform (initially, AbCellera's R&D costs were greater than their commercialization costs). AbCellera's partners use the company's antibody discovery platform in an effort to reduce uncertainty and costs and increase the accuracy of their drug discovery processes. Relative costs and timelines were adapted from prior literature[19] and secondary sources[30].

105M USD Series B also in May 2020, and the largest IPO in Canadian biotechnology history in November 2020 (ref. [28]).

Changing Traditional Risk-Reward Models

We observe a fifth entrepreneurial capability, changing traditional risk-reward models. Nanomedicine firms operate in environments of high uncertainty with development timelines up to 20 years and commercialization costs over US$1 billion. Software ventures, in contrast, typically enjoy much shorter development timelines and lower commercialization costs[9,19]. Hansen managed the profound risk that many nanomedicine firms face over long time horizons[9], due to their all-or-nothing blockbuster drug discovery model[9,32], by focusing on a partnership-based revenue generation model harnessing AbCellera's combination wet-lab/AI antibody discovery platform. These partnerships provided early recurring revenue and attracted federal funding to build more capital-intensive manufacturing facilities to further expand the scope of the company's end-to-end antibody platform, allowing it to bridge the Biotechnology Valley of Death. The Biotechnology Valley of Death[33] posits that many biotechnology firms fail at a critical juncture in their development due to a mismanagement of the trade-offs between quality, time and cost, and the inability to scale once a product is commercialized.

AbCellera's AI-powered antibody discovery platform allows for faster, lower cost and more accurate antibody discovery, improving upon existing Contract Research Organization wet-lab business models. Data generated from AbCellera's partnerships are fed back into its AI engine to improve its accuracy, creating a virtuous cycle which can be leveraged for rapid response. Both revenue generation models (antibody discovery and antibody discovery plus GMP manufacturing) support Hansen's vision of offering a complete, end-to-end antibody discovery and manufacturing solution to biotechnology and pharmaceutical companies[34], which can significantly accelerate their drug development. We demonstrate how Hansen developed and refined a high uncertainty breakthrough microfluidics technology pre-formation and positioned AbCellera to generate revenue in the short-term through its lower uncertainty antibody discovery platform in its quest towards developing capital-intensive manufacturing facilities (Fig. 2).

Another aspect of changing traditional risk-reward models was purposeful value chain positioning. A carefully developed value chain strategy can enable a nascent science-based venture to better position itself to capture additional value. Leveraging the pre-formation capabilities depicted in Fig. 1, Hansen built AbCellera's antibody discovery platform, recognizing the importance of an end-to-end value chain of sourcing, discovering, and delivering targeted antibodies to potential partners. Through continued internal technical capability development and later acquisition and integration of complementary technologies and firms (Lineage Biosciences, Inc. 2017; Trianni, Inc., 2020; OrthoMab, 2020), enabled by revenue generated from AbCellera's partnerships and government funding, Hansen achieved his vision of a complete source to delivery antibody value chain. This end-to-end antibody discovery platform now serves as their main revenue driver through over 100 partnerships with small biotechnology firms as well as large established pharmaceutical companies. These partnerships, most notably the one with Eli Lilly, enabled AbCellera's rapid pandemic response.

This purposeful integration of key technologies through acquisitions of related firms in the industry value chain meets an envisaged shorter-term market need while preserving AbCellera's ambitions in adding GMP manufacturing to their existing offering. This strategy is consistent with a systems integrator business model[32,35], but more nuanced in that by integrating technical capabilities to a strategic decoupling point, AbCellera de-risked its commercialization path. The decoupling point is the position in an industry value chain at which an innovator can deliver a modular product or service with low uncertainty experienced by their customer[36]. This value chain positioning strategy has been employed by advanced materials ventures[36] but is novel for biomedical ventures. Fig. 3 illustrates an antibody therapeutic industry value chain, with AbCellera's key decoupling points (antibody discovery and antibody discovery plus GMP manufacturing) highlighted. This figure shows that AbCellera is generating revenue in multiple parts of the value chain, while continuing to develop its specialized antibody capabilities, leading to an increasingly sustainable competitive advantage.

We note that directly targeting longer term capital-intensive opportunities may lead a nanomedicine firm to ignore short-term revenue generating opportunities which can provide a pathway to longer term survival, and yet care has to be taken to ensure that short-term opportunities and revenues do not lead to lock-in and hinder the commercialization of longer-term, breakthrough technologies.

Rapid Response in Context

When faced with pressing global health challenges, incumbent pharmaceutical firms, university research labs and university

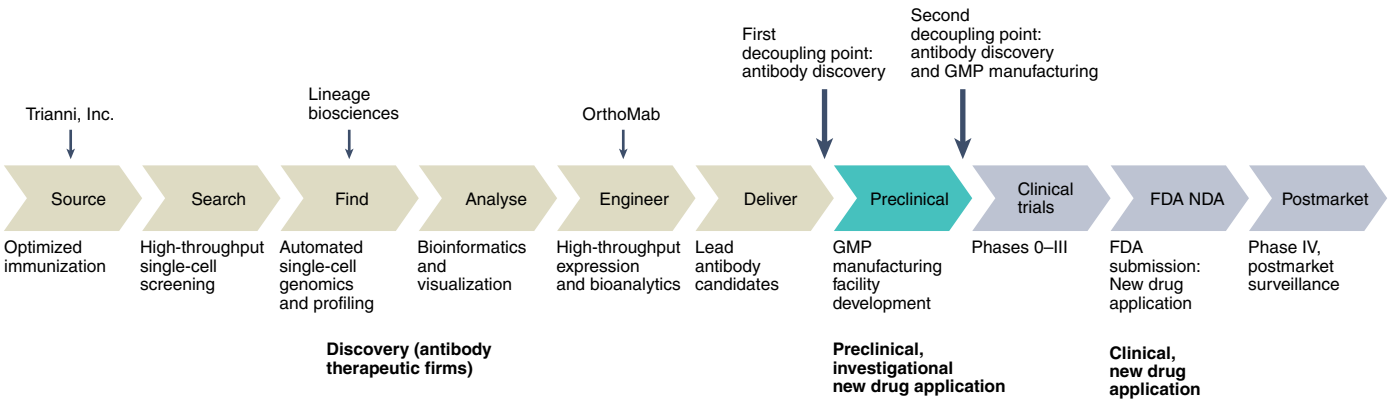

Fig. 3 | A complete antibody therapeutic industry value chain. AbCellera's first decoupling point represents its current antibody discovery platform. The external acquisitions required to reach its first decoupling point are noted above the value chain. Its future, second decoupling point adds GMP manufacturing capabilities. Figure adapted from: AbCellera Biologics Inc[30].

spin-offs are relied upon to produce rapid, broad-scale treatments and solutions. It can be argued that university spin-offs play the crucial role. Out of the six firms/partnerships that were provided funding by the US Department of Defence and the Department of Health and Human Services to develop, manufacture and distribute COVID-19 vaccines, university spin-offs were vital partners in the two — BioNTech (in partnership with Pfizer) and Moderna — that were able to rapidly produce an FDA Emergency-Use Authorized vaccine[37]. Conspicuously absent from the rapid response firms are incumbent vaccine manufacturers GlaxoSmithKline, Sanofi, and Merck (US) who have been vastly slower in their clinical development. Universities alone, without a spin-off venture, also appear to be at a disadvantage in rapidly commercializing novel therapeutics. Duke University and Vanderbilt University, who were participants in DARPA's P3 program[38], lagged in developing a COVID-19 therapeutic. By analysing the case of AbCellera, which, in partnership with Eli Lilly, produced the first antibody therapeutic for COVID-19, we demonstrate that well-endowed university spin-offs are better positioned to enable rapid response to global health crises.

Several vaccines and therapeutics have received FDA Emergency Use Authorization (EUA) for COVID-19 (Table 1). This data shows the prominent role of university spin-offs in rapid pandemic response through the development of novel vaccines and therapeutics. We note that university spin-offs were the first firms/partnerships that were able to produce a rapid response (Table 1). We acknowledge that not all pandemic responses involve novel vaccines or therapeutics; existing drugs can be repurposed for emergent diseases. However, even repurposed drugs are faced with long regulatory approval timelines and deployment challenges[39,40]. Large incumbent pharmaceutical companies may lack the necessary entrepreneurial capabilities and internal flexibility to rapidly respond to unexpected global health crises. Universities require a commercial apparatus to convert science inventions to downstream market-ready products, particularly in the nanomedicine domain. Universities can play a role in nurturing spin-off ventures, and well-endowed university spin-offs can produce rapid pandemic response, particularly when partnered with incumbents that have established regulatory, manufacturing and marketing expertise.

Recommendations

Academic scientists who develop entrepreneurial capabilities can make strategic, path dependent decisions that enable university spin-offs to rapidly respond to global crises. To support the development and deployment of such capabilities, we provide several recommendations for emerging nanomedicine ventures.

First, match the nascent technology to an initial target market pre-formation. Hansen chose the antibody market for his microfluidic technology long before firm formation, anticipating the value his antibody discovery and manufacturing platforms could create in responding rapidly to emergent infectious diseases. This technology-market matching capability is foundational to the emergence of breakthrough platform technologies[4,41].

Second, strategic timing of intellectual property protection can enable rapid response. We find evidence of early patenting and publication in high quality journals, which led to important future investments and partnerships. Nanomedicine firms with novel capabilities can consider early, broad, blocking patents to signal venture quality to potential investors and downstream alliance partners.

Third, attracting and mentoring members of the founding team pre-formation is an important entrepreneurial capability that shapes the trajectory and rapid response of a nanomedicine firm. Consistent with previous research on the influence of technical founding teams on firm performance[42], we find evidence of the benefits of Hansen's entrepreneurial mentorship of AbCellera's founding team, who were recruited from Hansen's academic lab (C. Hansen, personal communication, July 24, 2021). Such carefully nurtured founding teams are reservoirs of trust and technical know-how that can enable accelerated scientific and managerial decision-making.

Fourth, nanomedicine ventures can benefit from longer-term incubation within the university, considering incorporation once the technology has been sufficiently de-risked to meet investor expectations and timelines. Staying embedded in the university environment allows high uncertainty science-based ventures to build towards clinical viability while maintaining low overhead costs[43]. Longer-term incubation can also help build tacit knowledge through proximity with other research labs and cluster centres, the latter of which has been shown to enhance firm performance in the biomedical sector[44].

Finally, firms can change traditional risk-reward models by initially focusing on lower-uncertainty opportunities and by employing purposeful value-chain positioning to enable rapid response and create and capture more value. Nanomedicine firms targeting longer-term capital-intensive opportunities can explore intermediate value chain opportunities

Table 1 | Novel COVID-19 Vaccines and Therapeutics*

Company	Date of first US FDA EUA issuance	Name of intervention (type of intervention)	University spin- off/collaboration with a university spin-off	US government funding prior to EUA issuance
Eli Lilly and Company, and AbCellera Biologics Inc.	09 November 2020	bamlanivimab (therapeutic, mAb IV infusion)	Yes	US$375M (Oct. 2020)*** US$812M (November 2020)
	09 February 2021**	bamlanivimab and etesevimab (therapeutic, mAb IV infusion)		
Regeneron Pharmaceuticals Inc.	21 November 2020	casirivimab and imdevimab (therapeutic, mAb IV infusion)	No****	US$82.4M (February 2020) US$85.1M (June 2020) US$450.3M (July 2020) US$15.6M (November 2020)
Pfizer Inc. and BioNTech	11 December 2020	BNT162b1 (vaccine, mRNA)	Yes	US$1.95B (July 2020)
Moderna Therapeutics and NIAID	18 December 2020	mRNA-1273 (vaccine, mRNA)	Yes****	US$430.3M (April 2020) US$53.0M (May 2020) US$471.6M (July 2020)
Janssen Biotech Inc.	27 February 2021	JNJ-78436735 (vaccine, Ad26)	No	US$1.0B (August 2020)

EUA, Emergency Use Authorization; mAb, monoclonal antibody. *Up to March 2021, using US FDA EUA data for novel COVID-19 vaccines and therapeutics. Kisby et al. (2021) provide a broader comparison of global EUA COVID-19 vaccines[49]. **In partnership with Shanghai Junshi Biosciences Co. ***AbCellera also received a 175.6M CAD investment from the Canadian government on 3 May 2020. ****Their platforms had been under development for several years prior to COVID-19 (Ebola treatment for Regeneron and Zika mRNA vaccine for Moderna).

for de-risking, particularly if they have lab generated data that can inform the development of lower cost computational platforms that can be licensed to, or used in partnerships with, other firms. These intermediate opportunities allowed AbCellera to forge critical partnerships, which provided early revenue and enabled its rapid response.

This case also offers lessons for university leadership and innovation policymakers. Early translational support, development of the highly qualified personnel (HQP) and incubation of the science-based venture were critical to its future success. Yet too few universities and research agencies provide scientist–entrepreneurs and their nascent ventures with such support. Early translational support could include skilled translational grant facilitators supporting principal investigators. Developing HQP could include entrepreneurship training in the STEM PhD curriculum, and teaching reductions for faculty who actively mentor students in science-entrepreneurship. Incubation support could include subsidized access to physical space and to core research facilities. Instead of supporting such translational activities and contributions, university incentives frequently serve to punish scientist–entrepreneurs who wish to create social and economic value, by only considering narrowly defined research publication metrics in their evaluation. Prolific researchers and scientist–entrepreneurs are advocating for university leaders to refine institutional frameworks to reward faculty for entrepreneurship activities by allowing such activities to partially fulfil core academic, teaching and service obligations, and to factor into tenure and promotion decisions[45,46].

Government too can better support translational grants and HQP development to align the incentives of academic scientists, scientist–entrepreneurs, and regional and national innovation ecosystems. While governments have reacted to the pandemic by providing extensive funding for the development and manufacturing of vaccines and therapeutics for COVID-19[37,47], international health security and finance policymakers now agree on the need to pro-actively mobilize discovery research for future pandemic preparedness and containment[48]. Research granting agencies and government research initiatives can build in support for longer term, strategic research endeavours aligned with national, regional, social, and economic goals, through the purposeful integration of early market feedback into a broader range of research proposals and by funding university-led science-entrepreneurship training.

Considering medium- and longer-term strategic priorities, innovation policymakers can make early investments to support nascent nanomedicine firms facing high technological and market uncertainty, and long commercialization timelines. We note that such mission-oriented funding (for example DARPA P3) was crucial to creating the platform technologies and ventures needed to combat the COVID-19 pandemic. So too were the decades of lipid nanoparticle drug delivery research that underpinned the most rapidly developed and efficacious vaccines[41,49,50]. The central role of government funding along the risk-reward continuum (from high uncertainty early-stage discovery research to support for vaccine and therapeutics manufacturing during pandemics) needs to be acknowledged so that the rewards of such risk-taking and public-funded innovation are distributed more equitably[51]. Such an alignment of funding, training, incubation support, and institutional incentives can enable a rapid response to global crises through the entrepreneurial capabilities of academic scientists. ❐

Andrew Park[1], Azadeh Goudarzi[2], Pegah Yaghmaie[2], Varkey Jon Thomas[3]✉ and Elicia Maine[2]✉

[1]*Peter B. Gustavson School of Business, University of Victoria, Victoria, Canada.* [2]*Beedie School of Business, Simon Fraser University, Vancouver, Canada.* [3]*School of Business, University of the Fraser Valley, Abbotsford, Canada.*

✉*e-mail: jon.thomas@ufv.ca; emaine@sfu.ca*

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References

1. Friedrichs, S. & Bowman, D. M. *Nat. Nanotechnol.* **16**, 362–364 (2021).
2. Maine, E. & Thomas, V. J. *Nat. Nanotechnol.* **12**, 93–98 (2017).
3. Zucker, L. G. & Darby, M. R. *Entrepreneurs, Star Scientists, and Biotechnology* (NBER, 1998); https://www.nber.org/reporter/fall-1998/entrepreneurs-star-scientists-and-biotechnology
4. Thomas, V. J., Bliemel, M., Shippam, C. & Maine, E. *Technovation* **96**, 102153 (2020).
5. Bolzani, D., Munari, F., Rasmussen, E. & Toschi, L. *The Journ. of Tech. Trans.* **46**, 335–365 (2021).
6. Leih, S. & Teece, D. *Acad. Manag. Perspect* **30**, 182–210 (2016).
7. Roberts, E. B., Murray, F. & Kim, J. D. *Martin Trust Center for MIT Entrepreneurship* **15**, 1–55 (2015).
8. Perkmann, M. et al. *Res. Policy* **42**, 423–442 (2013).
9. Pisano, G. P. *Ind. and Corp. Change* **19**, 465–482 (2010).
10. Arora, A., Belenzon, S., Patacconi, A. & Suh, J. *Innov. Policy Econ.* **20**, 39–93 (2020).

11. Arora, A., Belenzon, S., Patacconi, A. & Suh, J. *Harv. Bus. Rev.* https://hbr.org/2019/11/why-the-u-s-innovation-ecosystem-is-slowing-down (2019).
12. *New AbCellera-Discovered Antibody that Neutralizes Viral Variants of COVID-19, LY-CoV1404, Enters Clinical Trials* (AbCellera, 2021); https://www.abcellera.com/news/new-abcellera-discovered-antibody-that-neutralizes-viral-variants-of-covid-19-ly-cov1404-enters-clinical-trials
13. Teece, D. J. *Strat. Manage. Journ.* **28**, 1319–1350 (2007).
14. Helfat, C. E. & Peteraf, M. *Strat. Manage. Journ.* **36**, 831–850 (2015).
15. Gurdon, M. A. & Samsom, K. J. *Technovation* **30**, 207–214 (2010).
16. Rasmussen, E. *Int. Small Bus. Journ.* **29**, 448–471 (2011).
17. Freeman, C. *The Economics of Industrial Innovation* 2nd edn (MIT Press,1982).
18. Maine, E. & Garnsey, E. *Res. Policy* **35**, 375–393 (2006).
19. Maine, E. & Seegopaul, P. *Nat. Mater.* **15**, 487–491 (2016).
20. Beckman, C. M. & Burton, M. D. *Org. Sci.* **19**, 3–24 (2008).
21. *AbCellera and Lilly to Co-develop Antibody Therapies for the Treatment of COVID-19* (Eli Lilly, 2020); https://investor.lilly.com/news-releases/news-release-details/ab
22. License agreement between The University of British Columbia and Abcellera Biologics Inc. (The University of British Columbia, 2013); https://www.sec.gov/Archives/edgar/data/0001703057/000119312520299507/d29983dex106.htm
23. Hsu, D. H. & Ziedonis, R. H. Patents as quality signals for entrepreneurial ventures. In *Proc. Acad. of Manage* 1–6 (Academy of Management, 2008).
24. Singhal, A. et al. Methods for assaying cellular binding interactions. US patent 36523710P (2019).
25. Hansen, C., Lecault, V., Piret, M., Singhal, A. System and method for microfluidic cell culture. US patent 36221310P (2020).
26. Lecault, V. et al. *Nat. Methods* **8**, 581–586 (2011).
27. Hansen, C. L., Sommer, M. O. & Quake, S. R. Systematic investigation of protein phase behavior with a microfluidic formulator. *Proc. Natl. Acad. Sci.* **101**, 14431–14436 (2004).
28. Silcoff, S. *With Historic Financing, AbCellera Becomes Champion of Canada's Surging Biotechnology Sector* (Globe & Mail, 2020); https://www.theglobeandmail.com/business/article-bc-drug-maker-abcellera-raises-expected-ipo-price-amid-huge-investor/
29. Murray, F. The role of academic inventors in entrepreneurial firms: sharing the laboratory life. *Res. Policy* **33**, 643–659 (*2004*).
30. *Form S-1 Registration Statement: AbCellera Biologics Inc.* (SEC, 2020); https://www.sec.gov/Archives/edgar/data/1703057/000119312520299507/d29983ds1.htm
31. *AbCellera Closes Seed Round of Financing* (AbCellera, 2014); https://investors.abcellera.com/news/news-releases/2014/AbCellera-Closes-Seed-Round-of-Financing/default.aspx
32. Niosi, J. & McKelvey, M. *Journ. of Evol. Econ.* **28**, 1081 (2018).
33. Linton, J. D. & Xu, W. *Trends in Biotech.* **39**, 107–110 (2021).
34. *Identifying a Potential Drug Candidate for Human Testing in 90 Days* (AbCellera, 2020); https://www.abcellera.com/post/identifying-a-potential-drug-candidate-for-human-testing
35. McKelvey, M. *Health Biotechnology: Emerging Business Models and Institutional Drivers* (OECD, 2008); https://www.oecd.org/sti/futures/long-termtechnologicalsocietalchallenges/40923107.pdf
36. Christensen, C. M., Musso, C. S. & Anthony, S. D. *Res.-Tech. Manage* **4**, 12–18 (2004).
37. *How Much Has Been Obligated for COVID-19 Vaccines Under the DOD and HHS Partnership?* (GAO Science, 2021); https://ows.gaoinnovations.gov/the-funding
38. Sonne, P. *How a Secretive Pentagon Agency Seeded the Ground for a Rapid Coronavirus* Cure (The Washington Post, 2020); https://www.washingtonpost.com/national-security/how-a-secretive-pentagon-agency-seeded-the-ground-for-a-rapid-coronavirus-cure/2020/07/30/ad1853c4-c778-11ea-a9d3-74640f25b953_story.html
39. Galindez, G. et al. *Nat. Comp. Sci.* **1**, 33–41 (2021).
40. Beigel, J. H., Tomashek, K. M. & Dodd, L. E. et al. *New Eng. Journ. of Med.* **19**, 1813–1826 (2020).
41. Maine, E., Thomas, V. J. & Utterback, J. *J. Eng. Technol. Manage.* **32**, 1–25 (2014).
42. Eesley, C. E., Hsu, D. H. & Roberts, E. B. *Strateg. Manag. J.* **35**, 1798–1817 (2014).
43. Thomas, V. J. & Maine, E. *Int. J. Entrepreneurship Small Bus.* **37**, 271–287 (2019).
44. Maine, E. M., Shapiro, D. M. & Vining, A. R. *Small Bus. Econ.* **34**, 127–146 (2010).
45. Rasmussen, E., Benneworth, P. & Gulbrandsen, M. in *Research Handbook on Start-Up Incubation Ecosystems* (Edward Elgar Publishing. (2020).
46. Expanding integrative basic and applied research to accelerate service to society. *HRA* https://hibar-research.org (accessed March 2022).
47. *Backgrounder – Government of Canada Investments in COVID-19 Vaccines, Therapeutics and Biomanufacturing Capacity* (Government of Canada, 2021); https://www.canada.ca/en/innovation-science-economic-development/news/2021/02/backgrounder--government-of-canada-investments-in-covid-19-vaccines-and-biomanufacturing-capacity.html
48. *Financing the Global Commons for Pandemic Preparedness and Response* (Financing the Global Commons for Pandemic Preparedness and Response, 2021); https://pandemic-financing.org
49. Kisby, T., Yilmazer, A. & Kostarelos, K. *Nat. Nanotechnol.* **16**, 843–852 (2021).
50. Bigini, P. et al. *Nat. Nanotechnol.* **16**, 1164–1175 (2021).
51. Lazonick, W. & Mazzucato, M. *Ind. And Corp. Change* **22**, 1093–1128 (2013).

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The start-ups taking nanoneedles into the clinic

Nanoneedle start-ups are traversing the biotech valley of death — from fundamental university research into commercial development in advanced therapeutics and diagnostics. How can academics make the most of this opportunity?

Roey Elnathan, Andy Tay, Nicolas H. Voelcker and Ciro Chiappini

Nanotechnology has matured to the point where it provides exquisite solutions to key challenges across medicine and biology, as seen in the success of delivery nanovectors for COVID-19 vaccines[1]. Among these nanotechnologies, nanoneedles — vertical arrays of high-aspect-ratio nanomaterials — have emerged as a simple, controllable and powerful tool to efficiently access cells with minimal perturbation[2]. Nanoneedles are rapidly emerging as competitive solutions for sensing[3], and offer a path to transforming gene and cell therapies[4,5]. Realizing the transformative potential of nanoneedles is a work in progress. In this Comment, we discuss the burgeoning advances and strong commercial activities of nanoneedle technology through the eyes of leading researchers, entrepreneurs and venture capitalists — all of them major players in the evolution of a viable nanoneedle technology for sensing and clinical use.

Why nanoneedles are hot science

The cell is a crowded, dynamic environment, in which access and transport are highly regulated. Conventional intracellular delivery and sensing methods significantly perturb cell function, limiting their physiological relevance[6]. The genius of nanoneedles is their capacity to gain access to many cell types many times with minimal and transient disruption, for efficient delivery of advanced therapeutics (nanoinjection) and non-destructive sampling of a cell's state (nanobiopsy)[2]. Having shown their strengths in the lab[2], the commercial interest in nanoneedles has boomed, and has been captured by start-ups that are working to develop and implement nanoneedle products and services (Table 1).

Capturing market opportunities for nanoneedle technology

Cell therapies. Re-engineering patients' own cells to restore function and treat diseases is a major challenge in contemporary medicine. The scale of interest and investment in the cell therapy market is global, with a market size projected to expand at a compound annual growth rate (CAGR) of 14.5% from 2021 to 2028 (Table 2)[7]. We can now engineer cells and tissues that benefit patients, but their prohibitive costs and complexity make these advances inaccessible to almost everyone who needs them. The scalable, high-throughput genetic engineering required by cell therapies is poorly