INVESTING IN THE LONG TERM:

How funding basic science can support the next wave of discovery

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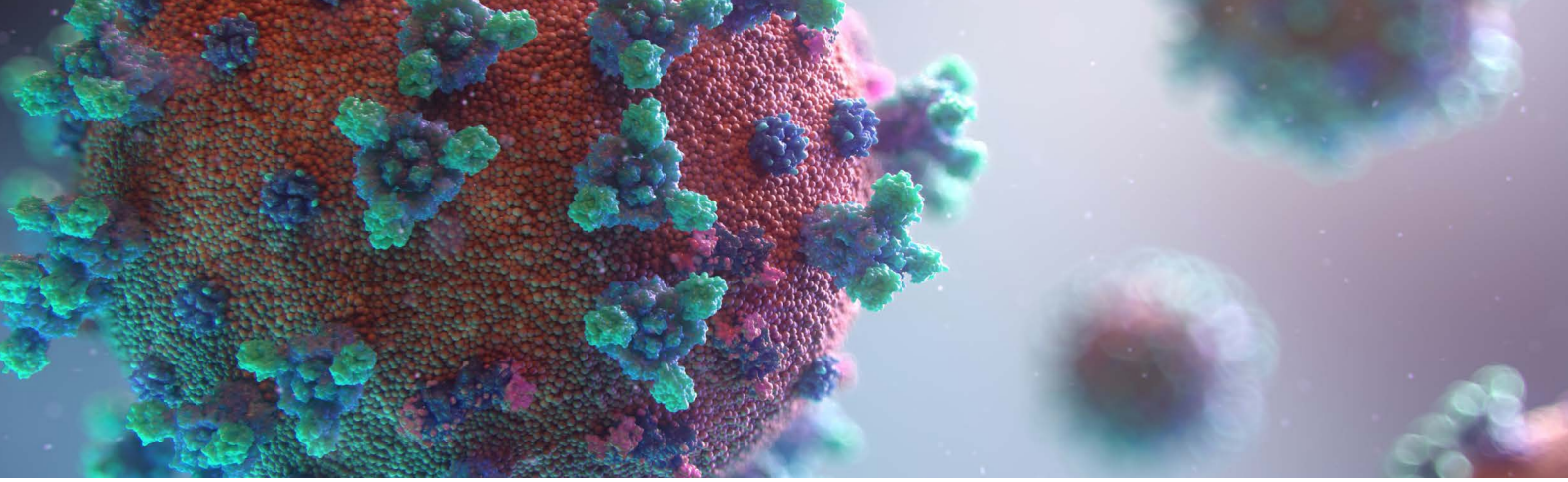
In July 2021, researchers from the University of California, CA, USA submitted a research paper to *bioRxiv* entitled, 'Borgs are giant extrachromosomal elements with the potential to augment methane oxidation'.[1] Borgs, which were previously unknown, are extra-long DNA strands with the potential to assimilate genes from diverse sources. Notably, in the case of the Lilac Borg, they play an important role in the oxidation of methane, one of the primary greenhouse gases driving climate change.[2] This is due to their capacity to 'super-charge' the abilities of *Methanoperedens* archaea – single-celled microorganisms that digest and destroy methane.[2]

Naturally, such potential led to both excitement and curiosity, with a *Nature* news article noting how the Borgs had perplexed scientists because of their structure and size.[2] In a post about the discovery, Jill Banfield, Professor in the Departments of Earth and Planetary Science and Environmental Science, Policy, and Management at the University of California and co-author of the research paper on Borgs, gave weight to those feelings, commenting, "I haven't been this excited about a discovery since CRISPR [clustered regularly interspaced short palindromic repeats]. We found something enigmatic that, like CRISPR, is associated with microbial genomes."[3]

A curiosity-driven approach to science

The discovery was born out of wetland soil and revealed through the analysis of around 10 million DNA snippets, and it is now seen as a finding with potentially global ramifications.[4] Yet, alongside the conversations about the ecological and technological potential of Borgs, Banfield highlighted the fundamental factor to which their discovery is attributed.

> *"You've got to fund basic science and you've got to respect basic science. This is where discovery comes from. It's about going out and finding out what's out there and describing it, putting together the story, and then you can get to the benefit of findings further down the line."*[5]



The curiosity-driven approach of basic science has been critical to the discovery of Borgs and may well pave the way for outcomes we can't yet predict.[6] Basic science is about the need to first ask the question, '*how does it work?*', before then asking, '*what is it good for?*'. We have seen researchers working in universities and institutes make discoveries through basic science that are subsequently built upon, helping to develop therapies for patients with serious diseases.[7]

CRISPR, a powerful tool for accurately editing genomes,[8] is singled out by Banfield as the most well-publicised example of the need to fund basic science.[5] While the technological outcomes couldn't be predicted from the offset, researchers knew that the discovery presented an ecologically and medically interesting defence system that was never suspected to exist.[5]
The outcome of such findings led to comments that the discovery of CRISPR represents the, "...golden age of disease research, thanks to the sequencing of the human genome and the development of other powerful technologies."[7]

Basic science and tackling COVID-19

The current global challenges presented by the COVID-19 pandemic have further underlined the need to provide funding for basic science.

Prior to the rollout of vaccines that have altered the global response to COVID-19, basic science helped identify the new coronavirus, determine how to detect it,[9] assess its susceptibility in humans[9] and monitor how it spreads and shifts.[10] This legwork has provided a platform for methods of applied science, research with a focus on immediate needs-driven applications,[11] to take us even further forward in our understanding of immunisation and the development of COVID-19 vaccines that can be easily adapted to provide protection against different variants.[12,13] Basic science and applied science work in collaboration, and collectively they have allowed us to react to the pandemic with remarkable speed, moving beyond the multi-year timeframes normally taken to create and approve new vaccines.[12] Recognising this, *The Lancet Microbe* notes:

> *Somewhere along the way the popular understanding of the sciences as basic* versus *applied seems to have been clouded. It is important to emphasise that the basic sciences are referred to in this way not because they are simple or introductory, but because they form the base...*[10]

This goes some way to explaining why there is still a need to shift beliefs around basic science and its role in defining long-term scientific advances, even though the impact of basic science is evident throughout the response to the ongoing COVID-19 pandemic.[12]

An investment in the long-term

Basic science is underpinned by researchers doing work without interest in practical applications; however, they frequently unearth scientific capital that can yield future results.[14]

> *In simple terms, today's scientific discoveries pave the way for tomorrow's medical advances.*[7]

It is for this reason that we see continued calls for the funding of basic science. As recently as July 2021, German developmental geneticist Maria Leptin, who at the time was looking forward to starting her term as president of the European Research Council in October, said that one of her first priorities in the role would be to persuade the European Commission to increase funding.[15]

Ultimately, examples of the role of basic science – from the discovery of heat-resistant enzymes[16] from bacteria in Yellowstone National Park, WY, USA to advancing the understanding of Borgs – are littered throughout our recent history. It is these discoveries that offer the foundations for our future advancements by asking the fundamental questions: *what, why, how*. Being prepared to invest in the long-term future without being distracted by short-term gains is something that should always be supported.[14]

1. Al-Shayeb B, Schoelmerich MC, West-Roberts J, *et al*. Borgs are giant extrachromosomal elements with the potential to augment methane oxidation. *bioRxiv*. 10 July 2021. https://www.biorxiv.org/content/10.1101/2021.07.10.451761v1. Accessed 3 August 2021; **2.** Dance A. Massive DNA 'Borg' structures perplex scientists. *Nature* 2021;595(7869):636; **3.** Banfield J [@BanfieldJill]. *Twitter*. 7:07pm 12 July 2021. https://twitter.com/BanfieldJill/status/1414647658786922496. Accessed 3 August 2021; **4.** Banfield J [@BanfieldJill]. *Twitter*. 7:07pm 12 July 2021. https://twitter.com/BanfieldJill/status/1414647665850130447. Accessed 3 August 2021; **5.** Banfield J. Interviewed by Nicholas Witts for Alpharmaxim. 14 July 2021; **6.** Lee C. Not so basic research: the unrecognized importance of fundamental scientific discoveries. *SITN*. 28 January 2019. https://sitn.hms.harvard.edu/flash/2019/not-so-basic-research-the-unrecognized-importance-of-fundamental-scientific-discoveries/?web=1&wdLOR=cF5BEA1BC-0A4A-4E9D-8F6D-033A1E9FD03F. Accessed 3 August 2021; **7.** Tessier-Lavigne M. In defense of basic science funding: today's scientific discovery is tomorrow's medical advance. *Cold Spring Harb Perspect Med* 2013;3(6):a019554; **8.** Vidyasagar A. What is CRISPR? *Live Science*. 21 April 2018. https://www.livescience.com/58790-crispr-explained.html. Accessed 24 September 2021; **9.** Bergeron J. Funding basic science research is crucial to our coronavirus pandemic responses. *The Conversation*. 6 May 2020. https://theconversation.com/funding-basic-science-research-is-crucial-to-our-coronavirus-pandemic-responses-133762. Accessed 3 August 2021; **10.** [No authors listed]. Funding basic sciences: a solid structure is built from the ground up [editorial]. *Lancet Microbe* 2021;2(2):e48; **11.** Governing Council of the Italian Society of Biochemistry and Molecular Biology, Board of the Italian Professors of Biochemistry. Basic and applied science at the time of COVID-19. *FEBS Lett* 2020;594(18):2933–2934; **12.** Moore JP, Wilson IA. Decades of basic research paved the way for today's 'warp speed' Covid-19 vaccines. *STAT*. 5 January 2021. https://www.statnews.com/2021/01/05/basic-research-paved-way-for-warp-speed-covid-19-vaccines/. Accessed 3 August 2021; **13.** Ball P. The lightning-fast quest for COVID vaccines – and what it means for other diseases. *Nature* 2021;589(7840):16–18; **14.** Risbridger GP. Editorial: the future of our basic science and scientists. *Mol Endocrinol* 2015;29(12):1673–1674; **15.** Abbott A. Biologist to lead Europe's premier research funder. *Nature*. 6 July 2021. https://www.nature.com/articles/d41586-021-01843-w. Accessed 28 September 2021; **16.** Having J. How a thermophilic bacterium from a Yellowstone hot spring is helping the fight against the COVID-19 pandemic. *USGS*. 30 March 2020. https://www.usgs.gov/center-news/how-a-thermophilic-bacterium-a-yellowstone-hot-spring-helping-fight-against-covid-19. Accessed 24 September 2021