



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

what is meant by big data. Huge amounts? A colossal amount of funding associated with it? Hypothesis-driven or investigative research by small groups is important but so is collaboration. Multidisciplinary research requires collaboration.

**What do you think are some of the problems faced by science today?**

Funding and recruitment are always issues. Directed funding opportunities in current fads or hot topics that reduce funding for other science areas. Ignorance and short-termism from politicians who only think of science if it fits their policies and does not harm their re-election. Actual antagonism to science and scientists, and disrespect for experts from certain world leaders and politicians. Brexit. Political interference and censorship. Expanding centralisation and administrative bureaucracy within institutions. Lack of public awareness or appreciation of science and scientists. Plagiarists, copiers and cheats. Religious fundamentalists and creationists. ‘New Age’ philosophies, crystal therapy, spiritualism, astrology and anti-science social media posts. Pseudoscience in product advertising. Fake and predatory journals, fake conference and journal invitations and yet more new journals. Probably there are a few more that I have not included.

**What do you think of the post-publication peer review of papers?**

Ridiculous, pointless and illogical for such obvious reasons that I don’t need to state to an educated readership.

**Do you support open-access publication?**

There are pros and cons. Of course we want science to be unrestricted and accessible to all. However, open access is not open at all as there is a cost, not feasible for some, and someone has to pay, usually the tax payer. This contributes even more to the rivers of income for increasingly powerful publishers who rely on a global army of unpaid researchers to write, review and edit the papers, solicit articles and edit the journals. Nice system. I wonder who thought of it?

Geomicrobiology Group, School of Life Sciences, University of Dundee, Dundee DD1 5EH, UK.  
E-mail: [g.m.gadd@dundee.ac.uk](mailto:g.m.gadd@dundee.ac.uk)



Essay

**Analogies and lessons from COVID-19 for tackling the extinction and climate crises**

Andrew Balmford<sup>1,\*</sup>, Brendan Fisher<sup>2</sup>, Georgina M. Mace<sup>3</sup>, David S. Wilcove<sup>4</sup>, and Ben Balmford<sup>5</sup>

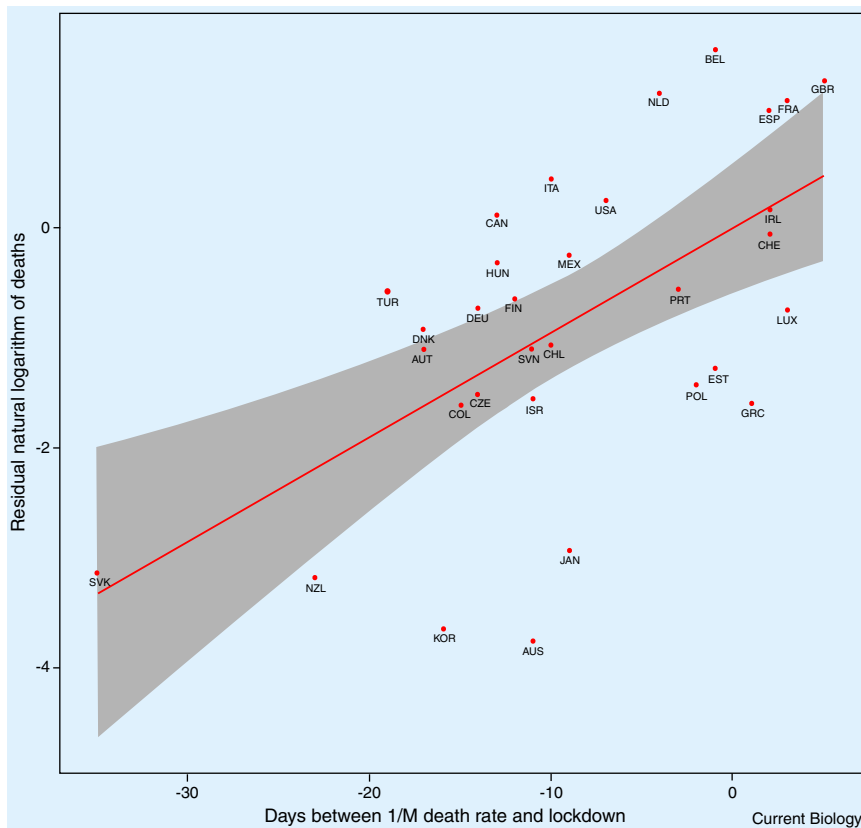
As environmental scientists working in countries whose COVID-linked deaths already exceed their military casualties from all campaigns since 1945, we believe there are significant messages from the handling of this horrific disease for efforts addressing the enormous challenges posed by the ongoing extinction and climate emergencies.

Like the climate and the extinction crises, the SARS-CoV-2 pandemic perhaps may at first have seemed like a relatively localised problem, far-removed from most people’s everyday lives. But a disease epidemic is, at its heart, a phenomenon of positive feedbacks, with each new case spawning others. Human impacts on our planet are likewise characterised by positive feedbacks. Unravelling ecological inter-dependencies and interacting threats accelerate the extinction of species. Anthropogenic warming can trigger state shifts in ecosystems, which further increase net emissions. Moreover, there are significant time lags in the dynamics of each problem — such as between infection and presentation of symptoms; between removal of habitat and the protracted extinction of species whose small and disconnected populations are thereby all but doomed to extinction; and between greenhouse gas emissions and the full effects of thermal expansion and ice-sheet melting on sea-level rise. These time lags mean that all three systems are also characterised by considerable momentum. As a result, left unchecked for too long, our ecological and climate impacts, like those of COVID-19, have swiftly grown to become existential threats [1,2].

Their lagged impacts, non-linear escalation and complex, still poorly-understood dynamics mean that recognising and mounting effective responses to each challenge require governments to listen to independent scientists. But, as we now know, such voices were and are being tragically ignored during this pandemic, as indeed were many years of warnings from epidemiologists and

wildlife-disease experts of the immense risks of novel zoonoses emerging from wildlife markets [3,4]. Scientists have likewise been warning for decades of the probability that human actions will be triggering a sixth mass extinction, and of the dire consequences of major human-induced shifts in the Earth’s climate. Yet, with these environmental catastrophes unfolding over decades — rather than months in the case of COVID — even now government responses to them, as reflected in international commitments, are patchy and inadequate [5,6].

We suggest that there are three other striking similarities among the COVID, extinction and climate crises. The first is that there is no substitute for early action. In the case of the pandemic, epidemiological modelling highlights the importance of early intervention [7,8]. Empirical analysis using date of lockdown as a proxy for the timing of intervention confirms this, revealing a clear link across OECD countries between when they issued strong ‘stay-at-home’ instructions and COVID-attributed mortality (Figure 1). A regression controlling for potential economic and demographic confounds suggests that had lockdown been enacted a week earlier, there would have been approximately 17,000 fewer deaths through to 21 May 2020 in the UK, and nearly 45,000 fewer in the USA. Likewise, delaying action on climate change such that the world experiences +2.0°C rather than +1.5°C warming will expose an estimated 62–457 million more of the world’s poorest people to multi-sector climate risks [9]. Species conservation actions are less likely to succeed the longer they are delayed [10], and the power–function relationship between species number and habitat



**Figure 1. The importance of early action in tackling the COVID-19 pandemic.**

The residual natural logarithm of COVID-related deaths per million people is plotted against when (in days) lockdown was introduced relative to when deaths reached one per million, for the 32 OECD countries which introduced restrictions on people's internal movements. To address potentially confounding variables the response variable is  $\ln(\text{observed deaths per million}) - \ln(\text{predicted deaths per million})$ , with the prediction derived from a linear model using as predictors national population density, % of the population that is urban, % of the population over 70, per capita GDP, Gini coefficient, the time between the WHO declaring a public health emergency and the country's 100th confirmed case, and total number of tests conducted. Overall model  $r^2 = 0.46$ ; the regression line shown has  $\beta = 0.0949$ ,  $SE = 0.0315$ ,  $p = 0.006$ ; shading shows 95% confidence intervals. A simpler model with no covariates has overall model  $r^2 = 0.38$ ,  $\beta = 0.1076$ ,  $SE = 0.0253$ ,  $p < 0.001$ . Further details in Supplemental information.

area means that, as conversion proceeds, marginal reductions in habitat area cause ever-greater species losses.

Second, in each case mounting effective and acceptable interventions requires decision-makers and citizens to act in the interests of society as a whole and in the interests of future generations. In the COVID crisis, young and working people have made sacrifices for the older and more vulnerable. For the climate and extinction crises, effective action requires that wealthier people forgo extravagance both for the present-day poor and for all future generations. Just as the 'harvest' of at-risk elderly people is not a socially acceptable price to pay for an early return to pre-pandemic

economic activity, neither is giving pre-eminence to economic growth at the expense of a substantial fraction of all species on Earth [1] or a stable climate. Instead, at the very least, the people, species and ecosystems most vulnerable to our everyday behaviours must be safeguarded through deliberate and well-enforced protection. More generally, viruses, circulating greenhouse gases and the processes by which we threaten nature do not remain confined to local or even national boundaries. Hence, tackling them effectively necessitates coordinated and simultaneous cooperation among individuals, subnational authorities and nations. The actions of powerful mavericks can threaten us all.

Third, even examined in narrow financial terms, as the immense toll of the COVID crisis on livelihoods and the global economy becomes clearer, estimates suggest that delayed action may ironically have reduced prosperity as well as cost lives. IMF forecasts [11] of economic growth through to the end of 2021 are lower in those countries with higher current death rates (compound growth in GDP per capita 2019-2021 vs COVID-related deaths per million has  $\beta = -3.63 \times 10^{-5}$ ,  $SE = -1.56 \times 10^{-5}$ ,  $n = 37$  OECD countries,  $p = 0.03$ ). Preventive actions to reduce the risk of future zoonotic pandemics appear to be highly cost-effective [12]. The notion that paying short-term costs may be vital to securing longer-term prosperity is echoed in several assessments of the overall economic consequences of responding to the climate and extinction crises [13–15]. On both environmental fronts, intervening now rather than delaying further is critical to securing our future wellbeing and that of our children and grandchildren.

Scientists are not inventing the threats of catastrophic climate change or of mass extinction. These threats are real and they are upon us. There are many steps we can take even now to greatly diminish both crises. Government and individual responses to the pandemic show us that swift and decisive changes are quite possible. In this light, the consequences of continued environmental inaction are too grave to contemplate.

#### SUPPLEMENTAL INFORMATION

Supplemental Information with details and data sources for the regression analysis can be found with this article online at <https://doi.org/10.1016/j.cub.2020.06.084>.

#### REFERENCES

1. Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O.U., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., et al. (2011). Has the Earth's sixth mass extinction already arrived? *Nature* 471, 51–57.
2. Barnosky, A.D., Hadly, E.A., Bascompte, J., Berlow, E.L., Brown, J.H., Fortelius, M., Getz, W.M., Harte, J., Hastings, A., Marquet, P.A., et al. (2012). Approaching a state shift in Earth's biosphere. *Nature* 486, 52–58.
3. Webster, R.G. (2004). Wet markets - A continuing source of severe acute respiratory syndrome and influenza? *Lancet* 363, 234–236.
4. Fan, Y., Zhao, K., Shi, Z.-L. and Zhou, P. (2019). Bat coronaviruses in China. *Viruses* 11, 210.

5. Tittensor, D.P., Walpole, M., Hill, S.L.L., Boyce, D.G., Britten, G.I., Burgess, N.D., Butchart, S.H.M., Leadley, P.W., Regan, E.C., Alkemade, R., *et al.* (2014). A mid-term analysis of progress toward international biodiversity targets. *Science* 346, 241–244.
6. Watson, R., McCarthy, J.J., Canziani, P., Nakicenovic, N., and Hisas, L. (2019). The truth behind the climate pledges. *Fundación Ecológica Universal-US*. Available at <https://drive.google.com/file/d/1nFx8UKTyjEteYO87-x06mVEkTs6RSPBi/view>.
7. Dagpunar, J. (2020). Sensitivity of UK Covid-19 deaths to the timing of suppression measures and their relaxation. medRxiv, <https://doi.org/10.1101/2020.05.09.20096859>.
8. Pei, S., Kandula, S. and Sharman, J. (2020). Differential effects of intervention timing on COVID-19 spread in the United States. medRxiv, <https://doi.org/10.1101/2020.05.15.20103655>.
9. Roy, J., Tschakert, P., Abdul Halim, S., Antwi-Agyei, P., Dasgupta, P., Hayward, B., Kanninen, M., Liverman, D., Okereke, C., Pinho P.F., *et al.* (2018). Sustainable development, poverty eradication and reducing inequalities. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, V. Masson-Delmotte *et al.*, eds. (Geneva, Switzerland: IPCC).
10. Martin, T.G., Nally, S., Burbidge, A.A., Arnall, S., Garnett, S.T., Hayward, M.W., Lumsden, L.F., Menkhurst, P., McDonald-Madden, E., and Possingham, H.P. (2012). Acting fast helps avoid extinction. *Conserv. Lett.* 5, 274–280.
11. International Monetary Fund (2020). *World Economic Outlook database*. Available at <https://www.imf.org/external/pubs/ft/weo/2020/01/weodata/download.aspx>.
12. Dobson, A.P., Pimm, S.L., Hannah, L., Kaufman, L., Ahumada, J.A., Ando, A.W., Bernstein, A., Busch, J., Daszak, P., Engelmann, J., *et al.* (2020). Ecology and economics for pandemic prevention. *Science* 369, 379–381.
13. Stern, N. (2007). *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press).
14. Hänsel, M.C., Drupp, M.A., Johansson, D.J.A., Nesje, F., Azar, C., Freeman, M.C., Groom, B., Sterner, T. (2020). Climate economics support for the UN climate targets. *Nat. Clim. Change* 10, 781–789.
15. Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., *et al.* (2002). Why conserving wild nature makes economic sense. *Science* 297, 950–953.

<sup>1</sup>Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK. <sup>2</sup>Environmental Program, Gund Institute for Environment, Rubenstein School of Environment & Natural Resources, University of Vermont, Burlington, VT 05405, USA. <sup>3</sup>Centre of Biodiversity & Environment Research, Medawar Building, University College London, London WC1E 6BT, UK. <sup>4</sup>Woodrow Wilson School of Public & International Affairs, Princeton University, Princeton, NJ 08544, USA. <sup>5</sup>Land, Environment, Economics & Policy Institute, University of Exeter Business School, Prince of Wales Road, Exeter EX4 4PJ, UK. \*E-mail: [a.balmford@zoo.cam.ac.uk](mailto:a.balmford@zoo.cam.ac.uk)

## Book review

# The evolutionary roots of belief

Jonathan Birch

*Why We Believe: Evolution and the Human Way of Being*

Agustín Fuentes

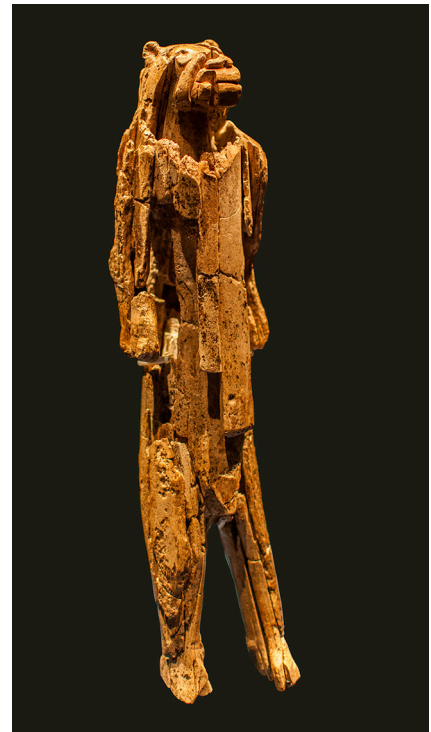
(Yale University Press, New Haven and London; 2019)

ISBN: 978-0-300-24399-4

I saw the Lion Man in the British Museum a few years ago, in an exhibition on the theme of ‘living with gods’ (Figure 1). The pictures do not do it justice. It is a 40,000-year-old mammoth-ivory sculpture with the head of a lion and the body of a human, pieced together from fragments found in a German cave. And it is utterly inscrutable. We have no idea who made it or what it meant to its sculptor. Many see a depiction of a non-existent, supernatural being. Then again, there were lions in Europe in the stone age, and shamans have been known to wear lion headdresses. Maybe it depicts a shaman, mid-ritual. The only certainty is that it is a glimpse of a lost and incomprehensible culture, the obvious meaning it once had now an unsolvable riddle.

The Lion Man brings out some of the difficult choices faced by anyone who sets out to write about the evolution of ‘belief’. Define the category of ‘belief’ narrowly, so as to include only straightforwardly *religious* beliefs, and your story starts a few thousand years ago — but it will miss out swathes of relevant prehistory, including objects such as the Lion Man. Define ‘belief’ as broadly as possible (for example, as any representation of the world that is available for the guidance of a wide range of actions) and there will be nothing distinctly human about it at all, given that beliefs in a broad sense are shared by a wide range of other animals. The story Agustín Fuentes wants to tell in *Why We Believe* is somewhere in the middle: a story about the ancient, but still distinctly hominin, psychological roots of what would eventually become religious belief.

This middle ground between belief in the broadest sense and full-blown religious belief is not easy to



**Figure 1. The Lion Man.**

Photograph by Dagmar Hollmann/Wikimedia Commons (CC-BY-SA 4.0).

define. Fuentes offers the following attempt: “belief is the ability to draw on our range of cognitive and social resources, histories and experiences in order to ‘see’ and feel and know ‘something’, and to utterly invest wholly and authentically in it such that it is one’s reality” (p. 177). This is very vague indeed, but it’s hard to imagine a definition that could capture the intended target phenomenon without being vague. I can live with the vagueness, but I’m sceptical of the suggestion that, if we “utterly invest wholly and authentically” in ‘something’, we can make it reality. This is a magic power we do not have. What we can do is create images of what we believe, such as the Lion Man. We can inscribe our ideas, myths, lore and fictions on the walls of caves and into ivory. What we can’t do is bring a non-existent being into existence just by believing in them.

The ability to inscribe our ideas on material objects seems likely to have originated in toolmaking. As Fuentes notes (pp. 38–43), the bifacial stone tools of the late Acheulean period around 600,000–300,000 years ago (tools generally known as handaxes