Make me a test and I will save the world

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Make me a test and I will save the world: towards an anthropology of the possible in global health

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What is deemed possible in the wake of failure? The global biotech industry's failure to develop affordable diagnostic devices for use in low- and middle-income countries (LMICs) has inspired a generation of humanitarian entrepreneurs to launch their own diagnostic start-up companies. This essay traces the rise and fall of one such start-up in Boston in the United States, Daktari, which developed a portable HIV testing device in the 2010s. I show how the alignment of humanitarian and economic valuations in a single diagnostic device depended on the ability of the start-up's founders and employees to synchronize the distinct tempos of financial capital, humanitarian design, and global health standards. Yet their failure to achieve this synchronization does not simply offer another story of biotech hype and speculation, the generation of promissory value at the expense of actual things. Instead, the essay examines the hopes and expectations that the firm's employees invested in the device's material qualities, manufacture, and distribution. What, I ask, is the meaning of failure, and its material remains, when it is measured against humanitarian rather than solely commercial expectations? The essay concludes with some reflections on the aftermath of failure in humanitarian entrepreneurship, examining the questions that Daktari's demise poses for understandings of what is possible and desirable in global health.

> Most of what we assume to be immutable has been, in other times and places, arranged quite differently, and therefore … human possibilities are in almost every way greater than we ordinarily imagine.
>
> David Graeber, *Possibilities* (2007: 1)

'I have one in my basement'. It is spring 2019 and Aaron Oppenheimer, former Vice President of Product Design and Development at Daktari Diagnostics, is speaking to me in a trendy health food café surrounded by students on laptops and mismatched wooden tables. We are just a few blocks from Harvard Square in Cambridge, Massachusetts. We have only just met and I am wondering whether it is appropriate to request a visit to his basement.
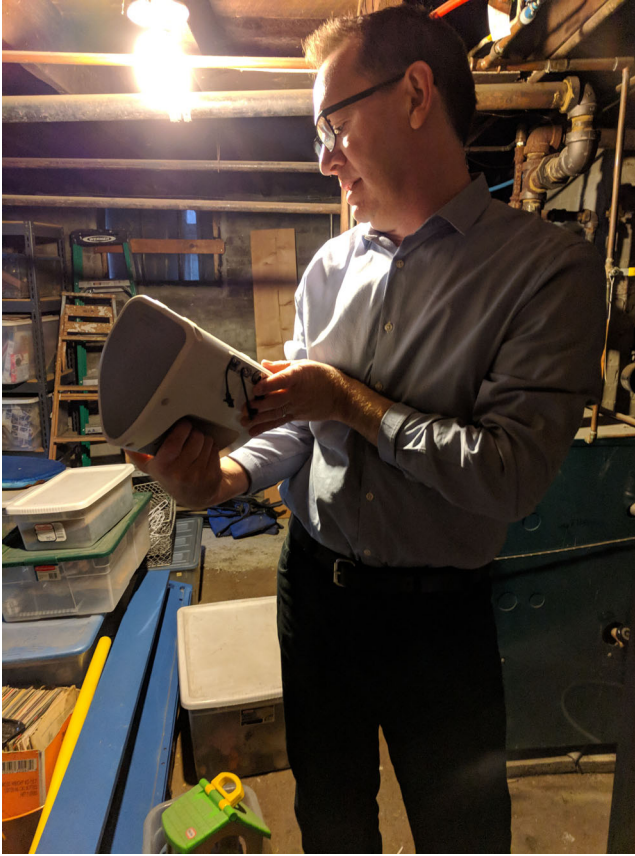
Figure 1. Aaron with his portable CD4 machine. (Photograph by the author.)

'Can I see it?'
'You want to come to my basement?'
'Yes'.
'I had better call my wife'.

A few minutes later, I am in Aaron's car on the way to his home: a modest clapboard house in a nearby residential side street. We are greeted by his amused wife and pass by their two children doing homework in the kitchen before Aaron opens a door in the hall and we descend the steps into his basement. The room is packed full of boxes and shelves and Aaron rummages around for some time, pushing sledges and hockey sticks out of the way. 'Here it is!' he calls eventually, extracting a scuffed white plastic storage box from the clutter which has 'Museum' scrawled on its side in black marker. He takes the lid off and removes an object that resembles a 1980s cassette player: a white moulded plastic box with a thick carry handle, a small screen, a few clunky push buttons, and a rectangular cassette tape-sized opening (Fig. 1). Having kept up a constant, excitable patter since we left the café, Aaron now falls silent, looking mournfully at the object he holds in his hand. Eventually, he hands it to me, watching expectantly as I examine the machine. 'I think we all took one', he says. 'We each have one in our basement or the box under our desk. For the memories, I guess'.

Figure 2. Daktari promotional image.

The object we are looking at is a Daktari CD4 machine, a portable testing device designed to inform doctors whether or not a patient infected with HIV should be started on antiretroviral treatment. Since the HIV virus attacks CD4 cells (a type of white blood cell that plays an important role in the immune system), the degree to which a person's CD4 count has fallen provides a good indication of how far the disease has progressed. Until 2016, CD4 counts were recommended by the World Health Organization (WHO) as the basis for establishing whether to initiate antiretroviral treatment. But many African clinics did not have access to the expensive laboratory equipment or technical expertise required to carry out a CD4 test. Drawing on novel electrochemical sensing technology developed in a research lab at Massachusetts General Hospital, the Daktari device could count CD4 cells present in a drop of blood in under fifteen minutes,[1] was battery-powered, and fitted in a backpack. With the development and commercialization of this accurate, portable, easy-to-use, rapid and affordable machine, the founders of Daktari – which means 'doctor' in Swahili – hoped to revolutionize access to HIV testing and treatment in Africa. The company's slogan was 'Today, there is no place out of reach' (Fig. 2).[2] Yet, by 2019, when Aaron excavated his Daktari machine from his basement for me, it was clear that the machine was not going to reach anywhere, and Aaron was still reflecting on the company's failure. Just what had gone wrong and why?

Elizabeth Holmes, the notorious founder of the once-celebrated diagnostics start-up Theranos, might be asking herself the same question, but I doubt that she has a carefully preserved Edison machine in her basement. The past few years have seen a litany of high-profile North American start-up failures, from WeWork's much-hyped and over-valued co-working spaces, to Theranos's once-vaunted Edison machines, which Holmes claimed could run hundreds of medical tests on a drop of blood but which, it turned
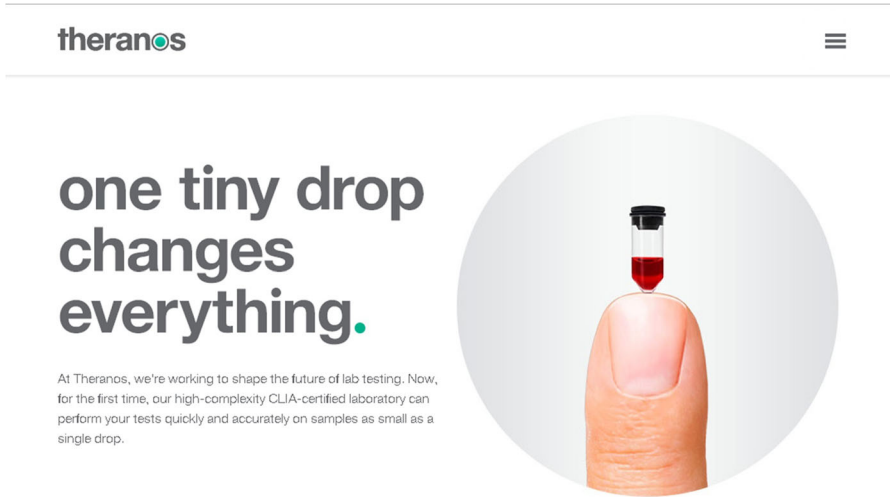
Figure 3. Theranos promotional image.

out, never reliably functioned, the company's tests instead actually being performed on conventional blood analysers manufactured by other firms. In the early 2010s, overlaps between Daktari's and Theranos's claims to 'point-of-care' diagnostic innovation were the source of some consternation to Daktari's founders because Theranos, it seemed, was so far ahead. Potential investors would often ask Daktari's CEO what it was doing that Theranos couldn't already offer. Even the promotional materials of the two firms overlapped, both playing on the scalar contrast between a tiny sample size and their technology's expansive testing possibilities: Theranos emphasized the vast numbers of tests that could be run on a single 'nanotainer' of blood (Fig. 3); Daktari emphasized the universal reach of a portable testing device that required only a drop.

The Theranos story is often depicted as a morality tale about the 'fake it 'til you make it' mentality endemic to Silicon Valley start-up culture; a story of how the pressures to raise investment, the ready availability of venture capital, and a permissive corporate legal environment encourage start-up founders to 'hype' their products and make promissory statements that they hope – but don't know with any certainty – they will be able to fulfil in the future. Many journalists have suggested that Theranos's downfall stemmed from Holmes's misguided attempt to transfer this approach from the tech start-up to the world of healthcare.

Anthropologists and science and technology studies scholars have made similar observations about the speculative cultures of biotech innovation in the United States (e.g. Cooper 2011; Martin 2015; Petersen & Krisjansen 2015; Robinson 2019; Sunder Rajan 2006; 2012). Protected by safe harbour legal provisions that protect the performative nature of promissory statements issued by firms so long as they are acknowledged to be 'forward looking', the sector is shown to be characterized by a form of 'speculative capitalism' that determines the value of a firm by its projections for future growth rather than the current market value of its manufactured commodities (Birch 2017; Sunder Rajan 2012). The result has been a skyward global financial valuation of the life sciences biotech sector, paradoxically accompanied by a dearth of actual

products and services produced by life sciences firms. The dissociation of value from the development of products and services, Kean Birch (2017) argues, follows from practices of financialization that transform the future value of a firm's assets into a tradable resource. Echoing popular critiques of Theranos, social scientists have suggested that, since biotech firms trade on 'hype' rather than 'commodities', they might best be understood as elaborate tech Ponzi schemes (Mirowski 2012).

Daktari, which was founded in Boston, a city often touted as the East Coast's biotech answer to Silicon Valley, was very much a child of the life sciences-driven biotech boom. The CD4 device utilizes electrochemical sensing technology developed in a Massachusetts General Hospital laboratory; Daktari's founder, Bill Rodriguez, who was previously employed as an infectious disease physician at Harvard, was put in touch with the laboratory's lead bioengineer by the hospital's 'technology transfer' office; and many of Daktari's employees were graduates from or ex-employees of the city's medical schools and life sciences departments. But, unlike Theranos and the biotech start-ups described by Birch, Daktari did have a working product. Moreover, it was a product that was loved by the people who worked for the firm, like Aaron. As this essay will show, the existence of a highly promising, well-developed product did not protect Daktari from commercial failure. But the presence of the device in Aaron's basement, one of many such devices scattered across the homes of the company's ex-employees, also speaks to the limitations of speculative capital as a theoretical framework for explaining either what happened to the firm, or its founders' and employees' experiences of and responses to that failure. In this story, I argue, materiality matters.

By contrast with some biotech start-ups, making and selling things was at the heart of Daktari's mission as a firm. Moreover, the production of commodities was not viewed purely as a pathway to profit. Instead, the firm is one of many start-ups in the Boston Metropolitan Area that aim to leverage the city's scientific networks and infrastructure to help the world's poor. Marrying humanitarian concern with technological optimism, these start-ups often focus on the development of simple, portable, and affordable solutions to complex problems of poverty, from clean water to affordable drugs. Their mission builds on a growing ethic of humanitarian entrepreneurship on display in schools of design, engineering, and business across the United States (Cross 2013; Redfield 2016) that relocates the humanitarian frontline from the under-resourced clinics of the Global South to the fully equipped biotechnology labs of elite US universities. For the humanitarian entrepreneurs who establish and work for these start-ups, making and selling material things – rather than simply assetizing future growth projections – is crucial because things, they believe, save lives. Going beyond the ethical window dressing performed by many pharmaceutical and biotech firms, for whom the bottom line nevertheless remains essentially economic (Dolan, Garsten & Rajak 2011; Ecks 2008; Sunder Rajan 2012), humanitarian entrepreneurs seek to bring economic and humanitarian valuations of diagnostics into total alignment; to 'commensurate' the value of life and the value of commodities that sustain life (Ecks 2018) through the manufacture and sale of commodities that care (Cross & Street 2022).

In this essay, I draw on analysis of interviews, site visits, media sources, and company documents to trace the arc of Daktari's rise and fall through its founders' and employees' attempts to raise financial investment, develop and design the CD4 testing device, and market their product to global health purchasers. The commensuration of economic and humanitarian valuations in a single diagnostic device, I argue, requires extensive work to align diverse expectations of investors, scientists, international health

organizations, and governments across the product's life cycle. As Noral Engel (2020) has described, alignment work between multiple global health actors, users, settings, and phases of the life cycle is uniquely tricky for diagnostics because many of these elements remain uncertain, unstable, and contested across the development process. What, I ask, happens to the ethic of 'doing well by doing good' when trade-offs between a product's ethical and economic qualities are required, or when a product ceases to hold value for people on one side of that equation? And what does it mean to the humanitarian entrepreneurs themselves, whose chosen career path is premised on the same fusion of values that they seek to build into their products, when the alignment of humanitarian and economic valuations fails? This essay is thus concerned with what Catherine Alexander (introduction to this volume) describes as the less-explored side of an anthropology of ethics, engaging with what it means for humanitarian entrepreneurs' pursuit of a good life when the objects that embody that goodness (in the sense of both doing good and being a commodity) fail.

I begin with an overview of the historical rise of diagnostics as a global health concern, describing how Daktari's founders viewed themselves as working in the shadow of the biotech industry's failure to deliver life-saving devices to the world's poor. In this sense, I argue, Daktari's founders already understood their venture as coming 'after failure' – in this case, market failure. I then examine the processes by which Daktari's founders and employees tried and failed to transform and align the diverse expectations of investors and global health organizations. At a practical level, processes of value transformation and alignment depend on the temporal synchronization of distinct rhythms and tempos found in investment cycles, humanitarian design and development, and global health standards. Here I suggest that Noémi Tousignant's (2013) analysis of the intersection between materiality and temporality in a postcolonial Senegalese toxicology laboratory is helpful for considering the multiple tempos of humanitarian entrepreneurship. Tousignant describes how Senegalese scientists experienced material shortages in the laboratory as a loss of both the everyday rhythms of scientific research that were once enabled by that material infrastructure and the optimistic futures towards which those rhythms and tempos moved science forward. Daktari was operating in a very different cultural, geographical, and historical context from the Senegalese research laboratory that Tousignant studied in the early 2000s, and yet this attention to the intersection between materiality and temporality, I suggest, can provide insight into both why Daktari failed on its own terms, and, from the point of view of Daktari's founders and employees, what was lost with that failure.

I end with an exploration of the aftermath of failure for the people whose careers were entwined with the life course of the firm, showing how Daktari's failure also formed the 'roots' of its founders' and employees' future career trajectories. In so far as global health diagnostics always come 'after failure', I conclude with a discussion of what appears possible and impossible for humanitarian entrepreneurs in Daktari's wake.

After (market) failure

According to a report in the *Lancet*, 47 per cent of the world's population has little or no access to basic medical tests (Fleming *et al.* 2021). Given the centrality of diagnostic categorization to modern biomedicine (Rosenberg 2002) and the primacy of the laboratory in biomedical knowledge production (Cunningham & Williams 2002), the absence of access to diagnostic testing across much of the world is startling. Yet, until recently, the lack of laboratory infrastructure at a primary care level of health provision

went largely unacknowledged in international and global health circles. Extending laboratory infrastructure to peripheral health facilities was simply considered too expensive and logistically complex to achieve (Street 2017). It is only fairly recently that universal access to diagnostic testing has come to be deemed both necessary and feasible; in other words, to be viewed as something it is possible to 'fail' at delivering.

Universal access to diagnostics has come to be seen as *necessary* within multiple overlapping and sometimes contradictory global health logics. These include: rights-based concerns about access to (the correct) treatment in the wake of the African HIV epidemic; concerns about rising drug prices and antimicrobial resistance, both of which provide a rationale for limiting the prescription of medicines to patients who have received a definitive diagnosis (Chandler 2019); a renewed focus on disease elimination, which generates a need for diagnostics to help measure progress towards this goal (Taylor 2020); and concerns about emergent disease outbreaks, in which diagnostic tests can play a crucial role in clinical management, quarantine implementation, and surveillance systems (Kelly, Lezaun & Street 2022). Universal access to diagnostics has also come to be seen as *feasible* in light of scientific and technological advances that enable laboratory assays to be standardized and miniaturized within portable point-of-care devices, most notably in the development of automated benchtop PCR (polymerase chain reaction) testing platforms and in the development of lateral flow immunoassay tests using monoclonal antibodies and antigens (Beisel, Umlauf, Hutchinson & Chandler 2016; Engel & Krumeich 2020; Street 2017).

Nonetheless, the *Lancet* study points to the lack of progress in the development of point-of-care diagnostics designed for use in low- and middle-income countries (LMICs). Apart from some notable success stories, such as automated RT (reverse transcription)-PCR tests for tuberculosis and lateral flow 'rapid diagnostic tests' (RDTs) for malaria and, more recently, COVID-19, few point-of-care tests for neglected tropical diseases or the WHO's high-priority pathogens have been developed and manufactured by the world's biotech and pharmaceutical firms (Derda *et al.* 2015; FIND 2015). This lack of commercial availability for diagnostic products is often explained through the prism of market failure: the lack of incentives for the pharmaceutical and biotech industry to invest in the development and manufacture of diagnostic products targeted at populations who lack the resources to pay for them (Lezaun & Montgomery 2020). Since the turn of the century, a variety of initiatives and mechanisms have emerged aimed at incentivizing the commercial development of diagnostics, including public–private partnerships, seed funding programmes, advance market commitments, and target product profiles, in many cases spearheaded by the Bill and Melinda Gates Foundation, an early champion for increased access to point-of-care diagnostics. It was therefore in direct defiance of the perceived status quo of market failure, and with an acute awareness of their historical agency in transforming the possibilities of global health intervention, that Daktari's founders set out to develop their portable CD4 machine. It was in this sense that Daktari was seen by its founders as coming 'after failure' (see also Prince & Neumark 2022: 6).

Point-of-care diagnostics are an especially fertile area for Boston's humanitarian entrepreneurs, bringing together the city's unique combination of expertise in genomics, engineering, and data science to develop rapid, affordable, and simple solutions to medical testing in places without laboratory infrastructure. As Daktari's promotional materials and catchphrase exemplify, the attraction of the miniaturized

laboratory device relies in part on the manipulation of scale that it permits (Cross & Street 2022). Bruno Latour (1983) has argued that the research laboratory operates as a lever for scientists to 'raise the world', first through the scaling down and control of microbes within its walls and then through the scaling up and extension of the laboratory back into the world via field trials and the staging of public experiments. This play on scale, Latour argues, enabled the famous French microbiologist Louis Pasteur to overcome multiple political and social obstacles to the acceptance of an anthrax vaccine in the late nineteenth century, dramatically transforming French society in the process. The aspirations of diagnostic entrepreneurs are similarly predicated on grand ambitions for small things (Cross & Street 2022). The miniaturization of the laboratory into a portable, standardized, commodity form is precisely what enables it to (hypothetically) reach and work anywhere (Beisel *et al.* 2016; Engel, Van Hoyweghen & Krumeich 2014). The universal reach of the point-of-care diagnostic test thus underpins humanitarian entrepreneurs' hopes to reconcile the profit motives associated with biocapital and humanitarian needs to, if not 'raise' the world, then certainly to 'save' its poorest and most vulnerable inhabitants.

But reaching anywhere depends, first, on convincing investors that a market exists for such devices. In the early 2000s, Bill Rodriguez, who would go on to found Daktari, encountered the problem of market failure first-hand while working at the Clinton Foundation as its Chief Medical Officer. Placed in charge of the foundation's HIV treatment programmes in Africa, he found that many facilities were unable to do the testing that would enable them to determine whether treatment was required. Having worked at Harvard University for many years, Bill's first response was to query why Boston's booming biotech sector had not developed solutions to the need for diagnostics in African HIV clinics. His initial forays into the diagnostics industry revealed that very few large biotech firms had their own research and development base; instead, they tended to buy up small start-ups with established technology. But there were also very few start-ups focused on diagnostics for global health because of the challenge of raising initial investment for a product for which it was assumed there was no market.

Bill thought this reluctance on the part of venture capital funds to invest in global health technologies was misconceived. His time at the Clinton Foundation showed him that a buyer market for diagnostic tests did in fact exist in LMICs: rather than by the direct users and beneficiaries of the tests, this market was populated by global health organizations, NGOs, and philanthropic donors. With a better understanding of the latent demand and economic capacity in these global health markets, he believed that investors' attitudes towards global health diagnostics could change.

With his background in global health and his extensive connections across Boston's biotech sector, Bill saw that he was uniquely positioned to bring about this change. Success, in his words, would mean being able to 'demonstrate how to start up a [global health diagnostics] company and get it started, then sell it off'. From the beginning, then, Bill's goal was not only to get a single diagnostic product out there, but also to show that a viable market for humanitarian diagnostics existed in LMICs; that it was possible to raise venture capital for humanitarian diagnostics, and build a profitable business out of them.

Like many technology start-ups, there was a clear endpoint to Daktari's planned trajectory. The aim, ultimately, was to exit. For a start-up, exit means either progressing to an Initial Public Offering (IPO) or being acquired by a larger firm, both of which enable those who hold equity in the firm to recoup their initial investment, ideally with

a substantial dividend. Bill Rodriguez was aiming for an exit through acquisition. But getting to that finish line required that Daktari align the distinct rhythms and tempos of start-up investment, international standard-setting, and humanitarian design.

The investment cycle

The route towards a start-up 'exit' is often portrayed as a linear series of stages, consisting of ever-larger rounds of investment, which coincide with a firm's developmental milestones. The pathway starts with the seed funding stage, in which founders often depend on resources from family and friends to develop the initial technology and prototype for their product. Firms progress to raising 'Series A' funding from angel investors and venture capital firms (who are often looking for high-risk, high-return investment opportunities) in order to refine their product, establish a user base, and develop a long-term business model. This enables them to raise 'Series B' investment, allowing them to scale up their business and invest in manufacturing, and so on. At each stage, investors take an equity stake in the firm, with the stake being proportionally greater in the earlier stages to reflect the risk involved, meaning that as a firm moves through the funding series, their own stake in the firm is progressively diluted (see also Sunder Rajan 2006: 234-76).

Daktari benefited in its early stages from the free licensing of Massachusetts General Hospital's already fairly well-developed electrochemical sensing technology for counting CD4 cells. Along with Bill's reputation and contacts, this enabled the firm, like many of Boston's global health diagnostics start-ups, to attract seed funding from the Bill & Melinda Gates Foundation. But to turn what was essentially a promising laboratory-based technology into a portable product required a much more substantial injection of funding, obliging Bill to do the rounds of angel investors and venture capital firms.

In his early pitches, Bill emphasized the humanitarian qualities of the technology, saying, 'It was a pretty straightforward pitch: here's this enormous problem in the world, here's the technology, we understand the customers, and so we can build a viable business out of this and we can really help save people's lives'. This story had played well with the foundation, and with numerous tech journalists who dutifully championed the extraordinary life-saving capacities of the miniature CD4 device. Bill's humanitarian vision was also central to his charismatic appeal to many of Daktari's employees, who described his conviction that diagnostic products could save lives in poor countries as compelling, and in some cases as persuading them to give up well-paid jobs to join the start-up.

But it soon became clear that investors would not be equally dazzled by either Bill's humanitarian vision or its material manifestation in the CD4 machine, which at that point consisted of a tangle of plastic, tubing, and computers that were able to generate good data in a controlled laboratory setting. Over the course of several months, Bill learned to say nothing about saving lives. Instead, he told me, his pitch became: 'Great technology, big untapped market, no FDA [Food and Drug Administration] requirements for initial customer acquisition and sales and here are the numbers. I would just show your standard financial projections'. This pitch depended on demonstrating that while users could not pay for diagnostic tests, there was a huge market demand for them from global health donors. In many ways, Bill's most convincing selling point in this regard was himself:

> I had the advantage of being the person who was able to see this entire market from my perch at the Clinton Foundation. We had been working with every possible global customer, from governments in the developing world, UN agencies, the World Bank, private organizations, large and small NGOs like Médecins Sans Frontières [MSF] and PSI [Population Services International] and all the people who buy a lot of diagnostic products. We knew all of them, and I knew a lot of them by name, so I was able, I think, to inspire confidence that I understood the market and would be able to sell the right product to these customers. And I had these global health experts as diligence points, where potential investors could call them up and say, 'There's this guy who says he knows you and he's trying to develop this new diagnostic test. Would you buy it if it existed?'

On the basis of this pitch, Daktari managed to close deals with a combination of angel investment funds and small venture capital groups and used this funding to develop its technology into a prototype. In 2014, Merck Pharmaceuticals also came on board as a strategic investor, leading the firm's Series A and Series B funding rounds and enabling Bill to raise funds from a range of venture capital groups and hedge funds. For Bill and his team, the success of these early funding rounds was a huge achievement. Daktari had already demonstrated that it was possible to raise investment for small, commercial ventures with a humanitarian purpose.

But the staggered tempo of investment funding also poses significant challenges for any start-up. No investor is willing to commit to the full development pipeline of a new technology, and even within each funding series investors often set development milestones that must be met within fixed timescales in order for the next tranche of money to be released. As Aaron explained:

> Here's another weird thing about start-ups that you have to get used to: your bank account is always empty, because you raise money to get you to the next milestone, which means that when you're halfway to the next milestone your bank account is pointing towards empty. When you're close to that last milestone, you're out of money.

In other words, in practice a start-up's product development frequently lags behind its stage of funding. These challenges were even more acute for Daktari, whose founders needed to demonstrate to investors that their product could be delivered at low cost in global health markets. This required that they rapidly scale up their manufacturing in order to bring down costs. And yet scaling up manufacturing was impossible without substantial capital investment. All too often, the cycle of investment series and milestones can leave start-ups like Daktari in a Catch-22 situation: they cannot raise the next round of investment without already demonstrating the progress that they in fact need that investment to achieve. While start-up investment guides commonly map investment series onto linear stages of product development, manufacturing, and sales growth, in reality the tempos of investment and product development are often misaligned. As the next section shows, this is especially the case if one wants the product to actually work.

Iterative design

All the while that Bill was flying back and forth between the East and West Coasts of the United States, pitching Daktari's business plan to investment groups, Aaron was back in the small lab and office they had rented in Cambridge, Massachusetts, trying to build the product. Aaron had a background in electrical engineering and had moved to Daktari from a product design consultancy firm following a trip to Durban, South Africa, after which he had been inspired to put his skills towards more meaningful ends than designing high-end toasters.

If no place was to be out of reach for the Daktari device, Aaron realized this would require a lot of engineering and design work. That work had its own rhythm: it involved spending weeks on solving one design problem, only to discover that this had spawned a different problem elsewhere. Sometimes, solutions could be found in a day; sometimes, it took weeks or months of trial and error and, occasionally, it was necessary to abandon a certain design trajectory altogether and go back to the drawing board. The non-linear temporality of technology development has been well documented in science and technology studies (see Alexander, this issue). In design studies, the cyclical process of conceptualizing, prototyping, testing, and evaluating – which is frequently interrupted by false starts and disappointing outcomes – is captured in the concept of 'iteration', which recasts interim 'failures' as part of an ongoing creative process (Sharp & Macklin 2019). For Daktari's product developers, these non-linear design loops were intensified by the ambitious technical requirements they had set themselves. In order to ensure the CD4 device was appropriately designed for use in rural African clinics, it needed to be easy to operate, it needed to be physically robust, it needed to have substantial battery storage, and it needed to be easy to clean. But it also had to be affordable and designed for cheap manufacture, and this required that it be made from plastic. It took the product development team several years just to redesign the electronic chip from plastic and develop a new way to coat the CD4 antibody onto the plastic surface of the microfluidic cartridge.

Another key challenge the team faced was that of establishing thermal stability for the test. With their 'Today there is no place out of reach' strapline in mind, Bill and Aaron had set their initial product requirements for thermal stability at 35 degrees Celsius to eliminate cold chain requirements. But it turned out this was more easily said than done. By the time they found out that no one had achieved antibody thermal stability at 35 degrees Celsius when attached to a plastic surface, the original design decision was irreversible. It took the team's biological engineer, Marta Fernández Suarez, two more years to find a solution to the problem. By this point, their bank accounts were once again empty.

Synchronizing the cycles of capital investment with the iterative rhythms of humanitarian design was a major challenge, not least because the team were unwilling to compromise on the technical specifications. Their commitment to building humanitarian capacities into the material device sat in direct tension with demands from investors that they make linear progress through technical and growth milestones.

Nevertheless, by 2014, Daktari appeared to have pulled off this feat. Bill had clinched a deal with Unitaid to provide close to US$3 million for Daktari to work with CHAI (Clinton Health Access Initiative), UNICEF (United Nation's Children's Fund), and MSF on large pilot studies in seven countries, and to subsidize initial purchases. The plan was for the subsidized product to seed the market and help them raise the next round of capital investment for fully automated, large-volume manufacturing. From the perspective of their financial investors, this would ultimately enable the price to be reduced for global health sales, vastly increasing the attractiveness of the firm for potential biotech acquisitions.

Changing norms

In his pitch to investors, Bill had characterized the global health market as built on the sure foundations of donor funding. But, in truth, behind the purchasing power of donor-funded health organizations and philanthropic foundations lies a world of global

health standards and policies, largely presided over by the WHO. These standards and policies provide the 'health promoting infrastructure' (Andersen, Andersen, Petersen & Wahlberg 2020) on which global health organizations base their procurement. The deal with Unitaid was thus premised on the WHO's HIV treatment guidelines, which required treatment decisions to be based on CD4 testing. By establishing a medical 'need' for CD4 tests, these standards and guidelines therefore provided the foundation for both the test's humanitarian value and its potential market value. On the basis of current treatment guidelines, Daktari could depend on sales of its CD4 device to multiple UN-affiliated agencies and organizations, enabling them to provide investors with projections of rapid market growth.

Just as the worlds of start-up investment capital and humanitarian design have their own tempo and rhythm, so does the world of standard-setting in global health, which is guided by a commitment to progressive improvement in science, technology, and practice, gauged by regular updates and changes to guidelines and policies. In 2014, when the funding from Unitaid was secured, the treatment guidelines for HIV had not changed for several years and Bill and his colleagues at Daktari did not anticipate them doing so in the near future, in part because the technical infrastructure to support those guidelines, such as point-of-care CD4 testing, was only just making its way through the product development pipeline. Bill was aware that new evidence was emerging from clinics in the United States showing that HIV-positive patients had better outcomes when started on treatment immediately and then monitored using viral load testing, rather than waiting for their CD4 cells number to decline. At some point in the future, he anticipated that Daktari would need to pivot to viral load testing. But since even fewer African clinics currently had access to viral load testing equipment than to CD4 machines, with few point-of-care candidates in the pipeline, it seemed unlikely that the WHO would make a guideline change that would be near-impossible for HIV treatment programmes in African countries to implement.

So when in December 2014 the WHO announced that they were planning to change the treatment guidelines for HIV to viral load testing in the near future, the Daktari team were blindsided. Crucially for Daktari, the change in the guidelines removed the possibility of donor funding for existing CD4 tests, dismantling Daktari's pitch for investment on the basis of an untapped 'donor market'. Soon after the WHO announcement, Daktari hit another inflection point when they needed to raise investment for their new manufacturing line. 'We were going to run out of money', Aaron explained,

> And we couldn't go back to the board and say, 'Can you give us an infusion, because we're almost there?' Which is what you do when you're not quite at a technical milestone. Because it was clear there wasn't ever going to be a market. When you are trying to raise US$30 million to build a factory, the people that you get that money from, they Google 'CD4' and they find out that the WHO just said it's gonna go away. They say, 'Yeah, I would get a return on my investment but not as good a return on my investment as I could by doing something else'.

The finely tuned balancing act that Daktari's founders and employees had been performing between the milestone demands of investors and the iterative tempo of humanitarian design was dramatically destabilized by the WHO's lurch forward into an era of viral load testing. The failure of the Daktari team to anticipate the policy change followed from their assumptions about the organization's pragmatism and the belief that WHO officials would base their decisions about medical standards on the existing

diagnostic landscape. Instead, those officials made a different kind of ethical calculus, premised not on the incremental progress offered by new point-of-care CD4 devices but on the principle that medical standards should be universally applied; there shouldn't be one standard for HIV treatment in high-income settings with access to viral load testing infrastructure while another, associated with poorer outcomes, continued to operate in under-resourced settings. The WHO had previously received considerable flack for the lengthy delay in initiating antiretroviral treatment for HIV in LMICs (Farmer, Léandre, Mukherjee, Tarter & Kim 2001), and the current policy change signalled the organization's willingness, in the wake of those criticisms, to set aspirational standards in the understanding that doing so would force technological progress and usher future norms into the present.

Within weeks of the WHO's announcement, Unitaid had clawed back its grant to Daktari and investors were beginning to wobble. The board appointed a new CEO to oversee the process of winding the firm down, including exploring opportunities for selling off any of the firm's intellectual property (IP) and auctioning off its remaining material assets. It was at this point that many of the firm's employees launched their own salvage campaign, discreetly removing CD4 devices from the company offices and secreting them in their home offices and basements.

Aftermath

That a start-up for humanitarian diagnostics failed is in itself perhaps unremarkable. Failure is taken for granted, and often venerated, in the start-up sector. Cultures of tech entrepreneurship have become notorious for extolling the virtues of failure as a path to success. When 'fake it 'til you make it' doesn't pay off, the mantra simply becomes 'Fail again. Fail better', as per the much-quoted aphorism from Samuel Beckett (see also Alexander, introduction to this volume). Failure is, according to Harvard Business School's Shikhar Ghosh, 'a vitally important part of the start-up ecosystem' (cited in Xavier 2012). In the world of start-ups, failure has become something to plan and prepare for, a necessary rite of passage in the career development of an aspiring entrepreneur (see Alexander, introduction to this volume). Before failure, entrepreneurs might promote their technologies as quasi-fetishistic objects, shiny beautiful things whose 'game-changing potential' keeps them at their desks well into the night. But, after failure, that same product is refigured as simply a temporary pause in a longer entrepreneurial career.

The careers of Daktari's employees have indeed flourished in the years since the firm's downfall. Several employees described to me how they felt inspired by their time at the firm to continue to work in the global health diagnostics sector. Aaron Oppenheimer went on to work for another Boston start-up involved in the development of global health diagnostic information systems. Marta Fernández Suarez went on to work for the Foundation for Innovative New Diagnostics (FIND), a public-private partnership that assists diagnostic developers to commercialize diagnostic products in the global health marketplace. Following a stint at a social investment fund, Bill Rodriguez was appointed as Chief Executive Officer at FIND. Other team members whom I interviewed went on to work at other diagnostic start-ups in Boston, for global health organizations, or enrolled in medical school.

Yet this doesn't mean that Daktari's employees carried the failure of the firm, or the loss of the CD4 machine, lightly. Many employees remained attached to their salvaged

CD4 machine, describing its 'beauty', their attempts 'to save it', and their sorrow that it was 'too late':

> I think we all have an instrument and a cartridge just to remind us, bittersweet memories. It is hard to put into words how we felt. The people, the culture at Daktari, it was an incredible place to work. I wouldn't have changed that for anything (Anonymous, Field Trials Coordinator, Daktari)

> I have a couple just for nostalgic purposes. Everyone in the team took one. I have Bill's because he's in Botswana. Yes, I don't know where the rest of them [are] – I think we had to responsibly dispose of them with some of the other lab stuff. I know, it's so sad, it's heartbreaking. It really is. We thought about renting storage just in case of a resurgence or something, but no (Betsy Wonderly, Clinical Trials Director, Daktari).

For Betsy Wonderly, who had run early field trials of the CD4 machine in East Africa, the worst aspect of the firm's demise was that the technicians and clinicians with whom she had trialled the device had told her that it would make a difference to them. In that sense, she told me, even if the donor market of buyers had collapsed, the user market for the device was 'really there'.

Daktari's founders and employees loved the CD4 machine because they believed its technical capabilities and design specifications perfectly embodied their aspiration to provide HIV testing anywhere. And yet they were also acutely aware that the machine never went anywhere, nor saved any lives. Their continued belief in the integrity of the device prompted former employees to reflect on where else, if not in the development of the product itself, they had gone wrong. In some cases, employees blamed the WHO for its failure to take the existing diagnostic landscape into consideration in its policy decisions. But others were more self-reflexive, admonishing themselves for failing to take into account the fact that global health policy is fundamentally progressive and therefore always subject to change. Bill, for example, wondered whether they had really needed to solve the thermal stability issue for the first iteration of the product. Instead, he reflected, they should have got a simpler product out there earlier and built evidence of market demand, which would have made it harder for the WHO or their investors to pull the plug. Aaron, meanwhile, wondered whether they had brought a strategic investor, Merck Pharmaceuticals, on board too early. By doing so, this had pushed them to start developing additional technologies for the company's target US market, which did not include CD4 testing, so slowing down the development of the CD4 machine. Thus, while Bill dwelled on the tempo of humanitarian design and wondered whether it might have been speeded up, Aaron reflected on the tempo of investment capital and wondered whether it might have been slowed down. Diagnostic alignment is a fundamentally temporal process (Engel 2020).

Just as Tousignant (2013) describes the scientists who inhabit a materially depleted postcolonial laboratory in Senegal as experiencing that shortage of resources as a loss of past futures, so, when Daktari's founders and employees packed their CD4 machines into boxes, did they lose the future world of global health diagnostics that the device had once promised to bring into being. But that loss was not experienced as absolute. Instead, former employees spoke of how their experience at Daktari, and their love for the CD4 machine, had inspired them to continue to look for opportunities to bring that future into being. As Betsy put it of Bill, 'I think he definitely created a lot of waves that he doesn't necessarily give himself credit for, but his vision gave a lot of people the roots of their own vision, and I hope we'll see some success out of those and he'll be

able to see that it was worthwhile'. Such statements 'render failure not an endpoint, but a beginning', providing the basis for starting again (Musallam 2020: 32).

Conclusion

In his analysis of another high-profile technological failure – that of Aramis, a guided public transportation system planned for Paris in the 1980s – Latour (1996) ultimately suggests that the project was failed by the people involved in it, who didn't 'love' it enough to help it to adapt to changing social and political expectations. Likewise, the speculative nature of biotech innovation might be understood as lending itself to a deficit of care for the material products that firms promise to make; a deficit that was taken to its logical conclusion in the case of Theranos. But lack of love was certainly not the issue for Daktari's CD4 machine, which the firm's employees viewed as perfectly embodying their humanitarian aspirations. Rather than failing from a lack of love, I suggest that Daktari might be best understood as failing from a lack of temporal harmony between the distinct rhythms and tempos of biotech investment regimes, global health standards, and humanitarian design, which ultimately made the alignment of humanitarian and economic valuations of diagnostics impossible. Tension between the ethics and tempos of investment versus humanitarian design was to some extent anticipated by Daktari's founders, but the dissonance between Daktari's ethical mission to improve global health and the WHO's ethical mission to do the same came as a surprise that was ultimately fatal to the entire project.

Yet while Daktari ultimately failed to bring about the commensuration of economic and humanitarian value regimes in a single point-of-care diagnostic device, I have suggested that the firm's founders and employees did not experience this as an endpoint. Instead, their love for the machine inspired them to dissect the possible causes of the firm's failure so as to better place them to succeed in the future. While a focus on the CD4 machine or Daktari might invite a diagnosis of failure, zooming out to a biographical scale reveals the object's continued afterlife in people's ongoing and ever-hopeful projects of humanitarian entrepreneurship. As Catherine Alexander and Fabio Mattioli point out (this volume), attributions of failure are also a function of the temporal and spatial scale through which events are perceived (see also Latour 1996; Redfield 2017).

Daktari's failure did not appear to provoke a rethink among the firm's employees of whether market-based approaches to global health innovation can actually work. Instead, their reflections on the temporal misalignment of investment, global health standards, and humanitarian design emphasized the personal mistakes they had made and the possibility that, with a bit more tinkering, success might have been achieved. This tendency to refigure failure as unfinished business is remarkably common across otherwise ideologically opposed projects of social improvement. This can be seen in examples from development workers' rendering of project failures as 'technical' rather than ideological (Ferguson 1994); to twentieth-century Soviet planners' apprehension of failures of Soviet-style developmental modernity as 'turning points' in a process of continuous construction (Ssorin-Chaikov 2016); to late capitalism's seemingly endless capacity to enfold its failures within its own logics of creativity and innovation (Peck 2010; see also Alexander, introduction to this volume). Such accounts often focus on how the rendering of failure as the beginning rather than the end of a process enables ideological frameworks to remain intact and obscures the power relationships they produce. In the introduction to this special issue, Catherine Alexander similarly asks

what failure might make possible. In the case of Daktari, it is apparent that the firm's failure made possible both the future careers of its employees in the global health field and the reproduction of humanitarian entrepreneurship as an ethical framework for personal and global health success.

Yet anthropological analysis does not need to end here. Having followed several failed humanitarian diagnostic start-ups, many of which encountered very similar pitfalls to Daktari, I take empirical issue with my interlocutors' entrepreneurial optimism and question whether the alignment of investment capital, global health standards, and humanitarian design in the construction of a global health market for diagnostics is ever possible. What would it mean to treat Daktari's failure not as the 'roots' of further humanitarian entrepreneurship but as an endpoint (Miyazaki & Riles 2005)?

Such a position would involve recognizing that the push for progressive improvement in global health norms is always going to render treatment guidelines unstable, potentially making diagnostic tests obsolete soon after they come to market. The dependence on venture capital funds, whose investors often have little interest in the humanitarian credentials of a firm or product, is always likely to necessitate compromises in humanitarian design. And a firm's successful navigation of successive investment 'series' will always lead to the progressive dilution of founder stakes, potentially also diluting the humanitarian values with which the firm began. Even when start-ups successfully 'exit' by way of acquisition by larger pharmaceutical and biotech firms, there are no guarantees that those firms will continue to manufacture diagnostic goods for global health markets – and not simply extract from them valuable IP and focus instead on the development of products aimed at more lucrative insurance markets in the United States.

This brings me to the question of what is deemed possible in the wake of failure. Daktari, I argued, was understood by its founders to have been conceived in the aftermath of market failure. But another starting point might have been the failure of the twentieth-century developmental state, and of subsequent regimes of international and global health, to extend laboratory infrastructure to the point of care in the Global South. It is worth returning here to the fact that diagnostics were neglected for many decades in global health precisely because the extension of staffing, infrastructure, and supply chains to rural laboratories was deemed impossible. The challenge that Daktari faced in reconciling economic and humanitarian valuations of diagnostics in real time thus prompts the question: is the commercial development of rapid, portable medical testing products for under-resourced health systems any more possible than establishing universal laboratory networks?

If failure, like crisis, is a narrative device (Roitman 2014), part of the work it can do is to open up a search for alternative ways of doing things. To be an anthropologist, David Graeber argued, is to have 'a commitment to the idea that the world could possibly look very different than it does' (2007: 2). Acknowledging the failure of humanitarian diagnostics as an endpoint, I suggest, opens up those possibilities. Peter Redfield (2016; 2017) has taken issue with what has become routine anthropological criticism of global health technologies as 'magic bullets' or 'band-aids' on account of their failure to bring about comprehensive social progress, questioning the nostalgia for top-down, centralist planning that is often implicit in such critiques. One might say the same of my own invocation of universal laboratory networks as an alternative to visions of diagnostic markets. But the purpose of such a provocation is not to advocate for a single solution

so much as to make a comparison of possibilities. Rather than sharing in my Daktari interlocutors' unreserved love for their CD4 device, I prefer to share with Redfield (2016) an attitude of 'ambivalent care' towards the object. Caring about the CD4 device in Aaron's basement means sharing its founders' concern for the improvement of access to diagnostic services in under-resourced health systems. But Redfield points out that care can also involve doubt, uncertainty, and ambivalence. The conceptual value of (failed) humanitarian devices, he argues, is their capacity to provoke reflection on what we actually *want*. I suggest that the value of Daktari's CD4 machine is also its capacity to provoke reflection on what is deemed *possible* in global health, and to ask what other possibilities might come into view if we accept 'market failure' as an endpoint.

Acknowledgements

NOTES

[1] The original aim, as discussed in much of the media reporting around the product, was ten minutes, but the final device never achieved this level of speed.

[2] This was later changed to 'Anywhere.Care'.

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Inventez-moi un test et je soulèverai le monde : vers une anthropologie du possible dans la santé mondiale

Résumé

Après un échec, qu'est-ce qui semble possible ? L'incapacité de l'industrie mondiale des biotechnologies de développer des appareils de diagnostic peu coûteux pour les pays à faibles et moyens revenus a inspiré une génération d'entrepreneurs humanitaires qui ont lancé leurs propres *start-ups* de systèmes de diagnostic. Cet article retrace l'ascension et la chute de l'une d'entre elles à Boston aux États-Unis, Daktari, qui développa un dispositif portable pour le dépistage du VIH dans les années 2010. Les fondateurs et les salariés de la *start-up* devaient, pour faire concorder valeurs humanitaires et valeurs économiques dans un même appareil, synchroniser les temps différents du capital, de l'élaboration humanitaire et des normes de santé mondiales. Leur incapacité à y parvenir n'est pas seulement une autre histoire de bulle de biotech et de spéculation, de promesses de valeur aux dépens de la réalité. Les collaborateurs de la société avaient investi des espoirs et des attentes dans les qualités matérielles de l'appareil, sa fabrication et sa distribution. L'autrice s'interroge sur la signification de l'échec et de ses traces matérielles, quand on les mesure à l'aune d'attentes humanitaires et non uniquement commerciales. Elle conclut par quelques réflexions sur les suites de l'échec de l'entrepreneuriat humanitaire et examine les questions que pose le trépas de Daktari quant à la perception de ce qui est possible et souhaitable pour la santé mondiale.