

Cryovalues beyond High Expectations: Endurance and the Construction of Value in Cord Blood Banking

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Abstract

Cryopreservation attracts attention as a practice grounded in high expectations: current life is suspended for future use—to generate life, to save life, and to resurrect life. But what happens when high expectations in cryobanking give way to looming uselessness and the risk of failure? Based on ethnographic insights into the case of umbilical cord blood (CB) banking in Germany, this contribution investigates the liminal state of “non-failure.” Averting failure amid a lack of success in this field requires putting effort into the construction of value. The resulting practices and dynamics overflow generic stories of commercialization and instrumentalization of biological material and are best grasped as an expanded version of the recently coined notion of “cryovalue.” The long-term availability of cryopreserved CB facilitates the steady yield of social and economic capital beyond and after

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promise. Moreover, the value construction is reoriented from CB itself toward the socio-technical cryo-arrangements in which it is embedded. In exemplifying how it expands the understanding of the diversity of valuation and valorization practices, continuities, and economic endurance in cryoeconomies and bioeconomies, the paper advocates the study of their ambivalent and allegedly uneventful sites.

Keywords

cryovalue, cord blood banking, failure, endurance, value construction, cryotechnology

Introduction

Cryopreservation generates “cryofacts” (Friedrich 2020, 339), biotechnological artifacts stabilized in time and space to “*keep options of becoming*” (Friedrich 2020, 339, emphasis in original). As such, they are objectified, exchanged, instrumentalized, and valorized. Where many studies of science and technology (STS) focus on the role of cryotechnologies as effective facilitators of connectivity and commercialization (see Waldby 2019; van de Wiel 2020), this paper reveals the other side of that coin. What happens when there is no one waiting to move, utilize, or invest in certain cryofacts?

In line with recent scholarly work that explicitly foregrounds cryotechnological dimensions of the life sciences, bioeconomies, and biopolitics (Radin 2017; Radin and Kowal 2017a; Kroløkke et al. 2020; Katz et al. 2020), this contribution explores what it means and entails when social practices crystallize around frozen, “suspended” (Lemke 2019, 2021) forms of life. In doing so, it scrutinizes a peculiar situation—when collections of cryopreserved biological material are at risk of becoming useless. In this article, I draw on ethnographic insights into umbilical cord blood banking in Germany. By tracing how practitioners engage with this situation, specifically with the absence of clinical routine and major breakthroughs in clinical research that would render samples “useful,” I will shed light on dynamics that rarely become visible when bioeconomies are investigated at sites defined by high hopes and expectations.

The argument presented here synthesizes three themes of discussions in STS. I begin by elaborating on the promises of cord blood (CB) banking and on their disintegration in Germany. As a rich source of hematopoietic stem cells, CB is donated for use in the treatment of various medical conditions

including leukemia, lymphoma, anemia, and immune system disorders (Horwitz and Chao 2017). It can also be stored for family use—a practice mainly enabled by hopes and ambitions associated with the future of regenerative medicine (Horwitz and Chao 2017). The fact that there are two contrasting “protocols for ordering cord blood” (Waldby and Mitchell 2006, 119) initially sparked considerable interest in this field from social scientists (see Waldby 2006; Dickenson 2007; Martin, Brown, and Turner 2008). Yet in Germany today, neither the established nor the expected clinical value of CB is sufficiently realized. The looming uselessness of both types of cryocollections puts public and private CB banking enterprises in a similarly precarious, pending state.

The present situation of German CB banking is neither one of success nor of irreversible failure. Later in this paper, I characterize it as “non-failure” and argue that this particular indefinite, liminal state is conditioned by the suspension of failure enabled by cryopreservation. In turning to how CB banks endure in unsatisfactory circumstances, I follow in the footsteps of scholars that shed light on the ambiguous downsides of hype and success in the realm of biomedicine and biotechnologies (see Tutton 2011; Fitzgerald 2014; Aarden 2017; Reardon 2017). In particular, I scrutinize the capacity to avert failure as it is sustained in the absence of a promising outlook.

Given low utilization rates, the status of donated (allogeneic) CB as “life-saving tissues” (Waldby and Mitchell 2006, 117) and the “speculative value” (Waldby 2006, 67) of family-owned (autologous) CB is no longer a given. In order to maintain their operations, both public and private CB banks need to actively engage in value construction. Consequently, my study of CB banking in Germany in its current liminal state of neither-success-nor-failure is an investigation of “values-in-the-making” (Dussauge, Helgesson, and Lee 2015, 269). After an overview of STS conceptualizations of value in bioeconomies in general and in the field of CB banking in particular, I make the case for extending the recently coined notion of “cryovalue” (Friedrich 2020). The first empirical section shows that efforts channeled into sustaining the value of cryofacts and averting failure might not always facilitate a “yield of optionality” (Friedrich 2020, 339), but they may at times yield social and economic capital. The second part of my analysis suggests that it is not necessarily the biotechnological artifacts that are valorized in contemporary cryoeconomies. Rather, the construction of value can also be oriented toward socio-technical cryobanking arrangements that generate liminality in the first place.

Overall, I zoom in on practices and dynamics that overflow generic stories of commercialization and instrumentalization of biological material.

As such, I explicitly do not mobilize a political–economic approach that seeks to capture generalizable features of contemporary biocapitalism (see Birch 2017). Instead, my contribution draws on an ethnographic inquiry into the contingencies of such general features as I encountered them at one of the somewhat disenchanting sites of today’s tissue economies. The paper concludes with remarks about how studying cryoeconomies and bioeconomies beyond hype and high expectations expands our understanding of value construction, stability, and change in the healthcare industry and the life sciences.

Methods and Material

The insights presented below were generated in a study of CB banking in Germany, which is part of a larger research project on cryopreservation practices in different domains: *Suspended Life: Exploring Cryopreservation Practices in Contemporary Societies* (CRYOSOCIETIES) funded by the European Research Council. The findings were derived from three inter-related bodies of empirical material, including field notes written over fourteen weeks of full-time participant and nonparticipant observation in a private CB bank (alias Y-Bank) and a public CB bank (alias Z-Bank). I also conducted semi-structured interviews with nine experts and practitioners whose work revolves around CB banking, stem cell research, and cryopreservation.¹ Lastly, between September 2019 and September 2021, I attended six CB-related conferences and workshops and read and analyzed scientific and industry reports, gray literature, media coverage, and marketing material dealing with CB, stem cell research, and stem cell transplantations.

This article seeks to “think with” the field of CB banking and its present situation in Germany rather than assessing the activities of particular enterprises. For this reason, I do not disclose the identity of the organizations and individuals discussed. I use pseudonyms and may arbitrarily change the gender identity of my interlocutors.

Cord Blood Banking: The Promises and the Present Situation

CB has been widely cryopreserved since the early 1990s, shortly after its clinical utility as a source of hematopoietic stem cells (HSCs) was established (Page and Kurtzberg 2017). Future parents interested in preserving CB as a stem cell resource can choose between either donating it or having

it stored for the exclusive use of their unborn child and its family members. Once declared as meant to be collected, CB is harvested right after birth and sent to a cryobank, where it is assessed and put into a liquid nitrogen tank within one to three days.

Public banking “is promoted with reference to a solidaristic moral economy of gift and altruistic participation in imagined community and nationhood” (Brown 2013, 98). Anonymously donated CB is an off-the-shelf alternative to bone marrow and peripheral blood, primarily for patients with blood malignancies (see Horwitz and Chao 2017). The main promise of cryopreserved allogeneic CB is that it is immediately available and there is no risk of donation requests being rejected. Moreover, the transplantation of CB does not require a full but only a partial immunological compatibility between donor and patient, thus offering a chance for patients for whom no proper match can be identified (Horwitz and Chao 2017).

Private CB banks, on the other hand, offer “stem cell depots,” as a commercial service, inviting clients to assume personal responsibility for their family’s health (see Waldby 2006). As autologous HSC transplantations are contraindicated for patients with hematological malignancies, family banks foreground the potential clinical value of such depots for siblings. These companies also assert that they are able to preserve several cell types contained in CB and the umbilical cord for the treatment of neurological conditions, type-1 diabetes, autism, and heart anomalies. While such applications are still mainly “considered investigational” (Kindwall-Keller and Ballen 2020, 1159), private CB banks emphasize their anticipated success. Thus, family banking is mainly grounded on the speculative promises of regenerative medicine and “the neoliberal appeal of investing a part of the body in the future” (Waldby and Mitchell 2006, 29).

Despite obvious differences between the two banking models, STS literature on CB in the 2010s has increasingly challenged the allegedly clear-cut distinction between private and public CB banks. Scholars have shown that both types of enterprises are “governed by economic principles” (Hauskeller and Beltrame 2016a, 429) and intertwined with market logics (Brown, Machin, and McLeod 2011; Hauskeller and Beltrame 2016b). Yet thirty years after CB banking began in Germany, the economic viability of these two models is no longer self-evident. In the absence of major breakthroughs in clinical research, family banks continue to offer their services in similar conditions of uncertainty as they did decades ago. Hence, the private CB banking market today exhibits a diversification of the business portfolio of its actors into other spheres of activity and is aggressively consolidating.² Meanwhile, the share of HCS transplantations with CB has decreased in

favor of bone marrow and peripheral blood (WMDA 2019b; Kindwall-Keller and Ballen 2020).³ Low utilization rates and high maintenance costs have left public banks all around the world “struggling to break even” (Magalon et al. 2015, 2). To prevent bankruptcy and relegitimize the significance of their operations, some organizations adjust their strategies toward more specific ways of rendering allogeneic CB units valuable—be it by collecting and making available transplantation units for ethnic minorities (Williams 2015; Beltrame 2020b) or by promoting novel uses of CB (Beltrame 2020a; Querol, Rubinstein, and Madrigal 2021). Characterized as being “on the rise” (Dickenson 2007, 84) and “taking off” (Brown, Machin, and McLeod 2011, 1116) ten to fifteen years ago, the field of CB banking is now in a state of uneventful stagnation, with some attempts at reordering becoming apparent.

Cord Blood Banking in Germany: A Plodding Walk on the Bright Side

CB banking does not unfold in the same way everywhere. Public CB banks only operate in forty-four countries worldwide—seventeen of these countries being member states of the European Union.⁴ The reasons are obvious: banking CB for nonprofit donation purposes requires costly certification schemes, sophisticated equipment, and partner clinics willing to undertake voluntary work. By contrast, the activities of family banks are much more expansive and widespread. Today, future parents in almost hundred countries have the option to store CB privately.⁵ However, in many cases, CB units are not processed and cryopreserved locally but sent to facilities abroad, to banks that provide services to clients in several countries (see Santoro 2009).

Germany is positioned quite favorably in the current geography of the CB economy. It is home to one of the ten largest family banks and to another owned by Europe’s leading group of commercial CB banks. Public CB banks, in turn, benefit from their unparalleled placement in the world of stem cell donation: Germany’s stem cell donor registry is one of the largest in the world.⁶ Such a standing comes with an extensive network of alliances and a high level of familiarity with regulatory, logistical, and technological demands.

Still and all, the favorable situation of both the private and the public banks in Germany is inherently fragile. Family banks operate in a market niche that does not provide enough room for many competitors. As a result, small enterprises are often forced to surrender while large ones can deflect

such defeat through mergers. Yet in the long term, riding the wave of business consolidation and exemplifying the benefits of this process is a double-edged sword. Hence, the same German CB bank that had hitherto actively facilitated market concentration through acquisitions has now been swallowed up by a foreign corporate group itself. Since July 2020, its leading shareholder has been an equity investment company that already virtually owns the largest group of CB banks in Europe and is seeking to establish a “pan-European umbilical cord blood bank.”⁷ This acquisition does not prevent the German family bank from retaining its original corporate structure and identity. Nevertheless, this shift in the shareholding structure has prompted questions about what this might entail for the local business site and what is going to happen to the jobs there (see Heitkamp 2020).

An executive at a family bank explained the problems in his business domain in terms of the difficulty of conjuring up “the principle of hope” (Interview, March 11, 2020) despite the uncertain realities of evidence production. A field note taken during an open day for potential clients at Y-Bank exemplifies this difficulty. It depicts my observations of the narrative strategies mobilized to link autologous stem cells to research activities:

Mr Fischer from Y-Bank proceeds with the presentation slides. He says that the transplantation of mesenchymal stem cells (MSCs) does not require a human leukocyte antigen HLA match—that clearly spoke for banking cord tissue, which contains MSCs. Fischer adds that researchers assume that such autologous tissue could become a “family drug” to be used by the entire family. . . . After Fischer has introduced the possibility of tissue engineering based on cell expansion techniques, a future grandmother asks him about the costs of such procedures. Fischer responds that this is something they cannot even estimate today. The woman continues by asking whether she could use the banked cells in case she ever needed to regenerate a cartilage in her knee. Fischer says that such a clinical application is not possible yet, as there are not that many clinical studies. He elaborates on the reasons for this: “Here in Germany, we are extremely cautious—because of the costs and the efforts.” That was different in the US, he adds. Fischer goes on, introducing existing studies on the clinical utilization of cord tissue at Duke University. (Field note, March 2, 2020)

The situation described here shows that future parents and grandparents are not content with abstract possibilities. Their questions, even the naive ones, can be quite concrete and compel CB bank representatives to

elaborate on the state of the art in clinical and translational research and to explain its gaps. Attempts to attract new clients amid a lack of watertight evidence require these representatives to render graspable how and by whom such facts may be constituted. Private CB banks in Germany may have emerged along with the “stem cell hype” and still operate in the “regime of hope” (Martin, Brown, and Turner 2008), but their current situation is far from being marked by optimism. Instead, it is primarily characterized by the necessity to sustain and authorize hope in the first place.

Optimism is not what I encountered when investigating the field of public CB banking in Germany either. The two largest German public banks were founded by large foundations, are internationally renowned, and have well-established relations with local hospitals and universities. However, as I learned from various decision makers and practitioners, none of these advantages have borne fruit in Germany itself:

- Interviewee : Nobody. Zero. And really, zero. I can't name you one clinic in Germany that has requested us in the last few years.
- Author : Uh-huh. And with regard to clinical trials—do you have any advice on whom to talk to?
- Interviewee : About umbilical cord blood here in Germany?
- Author : Nothing there either?
- Interviewee : No, nothing. Zero.
(Public CB bank executive, November 19, 2019)

Despite a prestigious and well-organized allogeneic CB banking sector, Germany is a wasteland when it comes to the treatments for which it was initiated in the first place. According to my interlocutors, there are currently neither clinical routine protocols nor trained professionals to facilitate the use of CB units for patients in need of a stem cell transplant. With the last clinical practitioner willing to transfuse CB units stopping his activities in 2007, it is now only used as a last option in generally hopeless cases (Public CB bank executive, November 19, 2019). In 2018, no German CB unit was released for a patient in Germany, and only one CB unit was imported (WMDA 2019a). In a world where half of all CB units are transplanted within national borders (WMDA 2019b), such a state of affairs leaves German banks with little chance of releasing enough CB units to cover high maintenance costs. An executive at Z-Bank described the endeavor as a “business model” that was “no longer viable” and the resulting atmosphere in his organization as one of “agony” (Field note, July 28, 2020). This does not come as a surprise, since the current situation imperils the use value of

public CB collections. After all, the “clinical usefulness [of allogeneic CB] arises at the point of redistribution, when it is transferred from one person to another” (Waldby and Mitchell 2006, 125)—a point mostly not reached in Germany.

Non-Failure: Endurance beyond Success, and the Role of Cryotechnologies

In the early 2020s, the field of CB banking in Germany is far from being hyped, cutting edge, or thriving. However, even though its present state fails to spark optimism among practitioners, it is not bluntly disappointing, outrageous, or disastrous either. Amid conditions that seem quite favorable at first glance and somewhat complicated when looked more closely, it persists in a constant state of pending. To be precise, German CB banks—both private and public—endure; they succeed at *non-failure*.

Fragile endurance as a form of economic and epistemic agency has recently gained a lot of attention on the part of ethnographers (see Hébert 2015; Tsing 2015; Ureta 2021). This line of empirical work sheds light on how resistance to failure is realized in practice, under various conditions and with different effects. However, the enactment of non-failure has not yet been studied at the intersection of the life sciences and the market economy. The reason for this might lie in the fact that biocapitalism tends to be investigated at its most exciting, provocative, and eventful sites—mainly when they emerge.⁸ Studies of emergent technologies are not only particularly insightful but also characterized by a clear division and alternation of success and failure. Neither genome sequencing endeavors nor national genome projects or post-genomic drug development are likely to fascinate social scientists at times when they have ceased to attract resources and to make (or outrageously break) game-changing promises—at a stage when they struggle to simply maintain their operations. What is more, such enterprises are unlikely to ever enter a long-term state of neither-success-nor-failure. The fact that both private and public CB banks can do this is not a coincidence: it is related to the temporality of their core activity. Unlike samples stored in biotech companies, CB units are preserved for an expected time span of up to 23.5 years in public banks (Broxmeyer et al. 2011) and up to a newborn’s entire lifetime in private banks.⁹ It is such time lags, enabled by cryotechnologies, that may render the liminal state of non-failure possible in the first place. Keeping biological material potentially viable and available for a long time buys time for the

economic actors who store them.¹⁰ It gives them the possibility of avoiding and postponing economic failure, even in the face of a lack of success.

Cryopreservation as a means of generating stasis and temporal suspension (Lemke 2019) is inherently grounded on the impetus of averting failure. As Radin and Emma Kowal (2017b, 11) aptly summarize, “[t]he denial that . . . fundamental Western projects may already be dead is often managed through practices of freezing.” They describe conservation projects such as “Frozen Zoos” as “weirdly optimistic” (Rose 2017, 152) techno-fixes that defer the moment when the systemic failure of capitalism becomes an irreversible state of affairs. The case of CB banking in Germany does not resemble one of these “techno-utopian dreams” (Rose 2017, 146) that primarily seek to circumvent the demise of capitalism. However, it is indicative of how cryopreservation endeavors and their maintenance ultimately extend the present and postpone irreversible changes (Wolff 2021). As such, it also demonstrates how a temporal suspension of the final use (or disposal) of biotechnological artifacts can perpetuate the formulation of expectations and concomitant practices of meaning- and value-making (cf. Borup et al. 2006). These practices tend to further uphold speculative uncertainty and suspend potential failure, thus sustaining biomedical and biotechnological projects as “in-formation”—not “well-bounded thing[s]” (Reardon 2017, 118) but contingent phenomena ordered by promises and the constant search for meaning.

Below, I elaborate on two modes of constructing value and their associated efforts into the maintenance of expectations and speculations. These intermediate practices of value construction sustain the state of non-failure and prevent the irreversible defeat of CB banking endeavors in Germany. In scrutinizing them, I draw on the notion of cryovalue proposed by the German philosopher of science Alexander Friedrich (2020).

From Biovalue to Biovalues, from Cryovalue to Cryovalues

CB banks turn matter that would otherwise become clinical waste into distinct biomedical objects, which come in sealed and labeled plastic bags with plenty of documentation attached. These objects are meticulously assessed, processed according to strict manufacturing norms, and preserved. Subsequently, they gain the legal status of medical products that can circulate across time and space to become part of clinical treatments. When it comes to such processes, STS discussions often revolve around the term “biovalue” coined and developed by Waldby (2000, 33):

Biovalue is generated wherever the generative and transformative productivity of living entities can be instrumentalised along lines which make them useful for human projects—science, industry, medicine, agriculture or other arenas of technical culture.

Like many other scholars concerned with bioeconomies and biocapitalism, Waldby demonstrates that living matter is incorporated into capitalist “projects of product-making and profit-seeking” (Helmreich 2008, 464). In particular, this line of work emphasizes that it is the technological means of manipulating and reformulating living matter that allow for much of today’s yield of profitability and vitality. Thus, biotechnologies such as genetic modification or cryopreservation make it possible to intervene in living processes in commercially promising ways (see Waldby 2002).

One of the most salient kinds of biotechnologies that add value to biological matter are stem cell technologies. As private CB banks both feed off the “dream of a regenerative body” (Waldby 2006, 61) and fuel it, they often serve as a catchy example of how the vitality of stem cells is turned into economic value. Their operations mobilize “projections of possible therapeutic applications” (Waldby 2006, 65) and capitalize hope as a commodity (Martin, Brown, and Turner 2008). Public banks, on the other hand, were initially analyzed as a counterpart to such a speculative mode of generating biovalue (Martin, Brown, and Turner 2008). In the 2000s, they were mainly discussed as instances of “an appealing counter-tactic to the privatisation of tissue and the commodification of the body” (Dickenson 2007, 105).

My insights into the German case align with recent studies of CB banking that discuss it as a hybrid practice that overflows formal classifications (Brown, Machin, and McLeod 2011; Hauskeller and Beltrame 2016b). Both public and family banks in Germany face a similar lack of success because the “molecular heroism” (Fortun 1998, 214) of cord-blood-contained stem cells remains unutilized on “a molar scale” (Fortun 1998, 214) of medical treatment. Attempts at upscaling the use value of CB and actually utilize the samples come to nothing due to factors that lie beyond the control of the banks themselves—be it the lack of clinical routine or the lack of formalized evidence. As a result, private and public CB banks alike either face irreversible failure or sustain the liminal state of non-failure.¹¹ The latter capacity results from efforts invested into sustaining at least some expectations and revivifying or reinventing the value form of CB collections. Sometimes, such efforts explicitly aim for the definition of new ways

in which CB units should circulate as a valuable source of vitality (Williams 2015; Beltrame 2020a, 2020b). However, my ethnographic work in Germany shows that redemptive forms of value reinvention do not always match the concept of biovalue as it was originally coined. They may rest on hopes for an instrumentalization of biological vitality, yet no longer necessarily primarily revolve around it in practice.

A context in which cryopreserved CB is no longer linked to high expectations of future surpluses of profit or health is what Beltrame and Hauskeller (2018, 11) have called a “peculiar configuration” of value production. They propose to detach the analysis of value and valuation in such contexts from “fixed explanatory categories” (Beltrame and Hauskeller 2018, 11). Instead, Beltrame and Hauskeller (2018) encourage STS scholars to study the different kinds of “engaged practices of the diverse actors involved” (p. 14) and the “multiple *biovalues* [that] are enacted and carry forth the biobanking bioeconomy” (p. 25, emphasis in original). This shifts the focus from an allegedly predictable and universal process of valorizing biological vitality to heterogeneous practices that construct different kinds of value (see Dussauge, Helgesson, and Lee 2015).

I follow Beltrame and Hauskeller’s advice to view (bio)value as multiple by discussing particular enactments of value in the field of CB banking—enactments that do not contradict but rather coexist with others that have already been depicted elsewhere (Waldby 2006; Martin, Brown, and Turner 2008; Brown 2013; Williams 2015; Machin 2016; Beltrame 2020a, 2020b). As I show below, practices of constructing the value of German CB collections amid inauspicious circumstances are not bound to any distinctive property of CB. Instead, their specificity is related to its technologically induced state: the state of being suspended—frozen and put into liquid nitrogen tanks for a long time. Thus, what gives form to the banks’ efforts of constructing value is not *what* they store but *how* they store it. To do justice to this fact, I draw on the term proposed by Friedrich (2020): cryovalue.

Friedrich distinguishes cryovalue from biovalue, emphasizing the pending nature of cryovalue. Cryovalue may or may not be realized as biovalue and is generated precisely due to this very optionality:

If “biovalue” refers to the “yield of vitality” produced by the biotechnical reformulation of living processes, then the “yield of optionality” produced by the cryopreservational suspension of living processes is the “cryovalue” of biotic artifacts.

Cryovalue can be converted into biovalue by thawing and using the frozen biota for specific purposes, but the yield of optionality typically exceeds the intended uses of cryofacts due to its potentialization. (Friedrich 2020, 339)

This conceptual proposal emphasizes the potentializing effect of cryopreservation (Hoyer 2017, 207). Drawing on the example of oocytes retrieved and stored by commercial fertility service providers, Friedrich points to the distinct value form of cryofacts, defined as the specific coupling of optionality and long-term availability that comes with suspension (Lemke 2021). Since biological material is cryopreserved as a matter of preparedness or “safeguarding” (Friedrich 2020, 335) and often remains unused while still being there, he argues, it can be enrolled in other relations that utilize and valorize it anew.

Friedrich’s notion of cryovalue is seminal because it explicitly addresses how cryotechnologically induced temporal suspension affects the construction and yield of value. In what follows, I suggest expanding this conceptualization so it can better include spheres of cryobanking that are not as vibrant and dynamic as oocyte freezing. My insights into the non-failure of German CB banks suggest that the absence of high expectations complicates the view that cryopreservational suspension and the “yield of optionality” are related in a straightforward way. I argue, in a similar way to Birch and Tyfield (2013, 313) with respect to biovalue, that cryovalue is not a singular “latent characteristic of a biological product, commodity, or resource.” The findings presented below indicate that optionality itself does not come naturally but may well be at risk of fading and become something that is in need of maintenance work. Moreover, my findings show that what is valorized may not even be the cryofacts themselves but the arrangements of material and social relations in which they are embedded.

Optionality in the Making

An investigator who is studying how mesenchymal stromal cells (MSCs) derived from umbilical cord tissue can reprogram immunity and suppress inflammation is receiving renewed support from the Cord Blood Association Foundation.¹²

Just as I am writing this section of the paper, I receive an email with an announcement of the renewal of a research grant. The funding is provided by the Cord Blood Association (CBA), which was founded in 2014 and “is

an international nonprofit organization that promotes both public and family cord blood banking and accelerates the use of cord blood and perinatal tissues to benefit patients and advance medicine.”¹³

An association of CB banks is funding a laboratory study on the anti-inflammatory potential of cells contained in cord tissue. Such announcements of grants and collaborations are often part of the many regular updates that I receive after having subscribed to the newsletters of the CBA, the Save the Cord Foundation, and the World Cord Blood Day (WCBD).¹⁴ It is precisely their ubiquity that is telling and worthy of attention when it comes to understanding the specifics of the value form of cryofacts beyond high expectations.

The fact that the “molecular heroism” of stem cells in CB has not been sufficiently translated “to a molar scale” of clinical application leaves CB banks around the world striving to realize this translation. This leads to establishing transnational associations, venues and conferences, which grant funding to lab and clinical studies and foster alliances among industry representatives and researchers. Thus, it is not surprising that the CBA was founded in the 2010s, at a time when CB was no longer “taking off.” Representatives of CB banks cannot simply lean back and observe how interest in CB stalls amid unfortunate circumstances. Instead, both private and public banks constantly engage in forging relations that keep it in researchers’ and clinicians’ sight (Williams 2018; Querol, Rubinstein, and Madrigal 2021). After all, they need expectations and speculations about possible uses of CB to be sustained. Otherwise, its optionality can quickly turn into uselessness.

As with other biomedicine-related expectations (cf. Tarkkala, Helén, and Snell 2019), the maintenance of CB-related expectations is a laborious task. It requires continuous meaningful interactions between various clinical, public, scientific, and industry actors (Tarkkala, Helén, and Snell 2019; Machin 2016; Morrison 2017). The recently discussed case of the Singapore Tissue Network shows how the absence of meaningful interactions in which the value of long-term preserved biological artifacts is (re)negotiated, ultimately leads to failure (cf. Aarden 2017). The enactment of the need to keep cryofacts a “matter of concern” (Latour 2004) rather than mere objects, on the other hand, generates social and economic capital. It materializes and is reproduced in organizations and venues such as the CBA and the WCBD but is not limited to public activities. It is also actualized in daily workflows in and around CB banks themselves.

During my research stay at Y-Bank, I met someone in charge of curating CB as a “matter of concern.” Dr. Dietrich told me that it was part of her job

to approach those whom she called local “therapeutic area experts” (Field note, March 11, 2020) such as directors of clinics and chief physicians to explore possibilities for collaborating in clinical trials. These trials needed to be investigator-initiated studies, because her interlocutors placed great emphasis on not compromising their reputation by being involved in industry-sponsored trials. By the same token, she had the impression that therapeutic experts were generally inclined to pursue joint projects because these made it possible for them to fund their scientific staff. Another employee of Y-Bank elaborated on their ties with local research institutes as being productive in the long term. He told me that from time to time, they were approached by scientists interested in initiating joint investigations. The latter, he explained, were funded by a third party—a regional development bank—and therefore created a “win-win situation” (Interview, March 6, 2020) for both Y-Bank and academic institutions. A few months later, I ran into one of Y-Bank’s representatives at a symposium of a government-initiated economic development program that funds the regional biotech “ecosystem.” Obviously, frozen CB’s “sticky” presence gives Y-Bank opportunities to establish lasting alliances that occasionally pay off. It mediates the creation of localized economic and social capital beyond clear-cut promises and temporary goals.

Tracking such dynamics through the case of CB banking brings to light a peculiar kind of tenacity. They have outlasted the “discredited ambitions surrounding regenerative medicine” (Brown 2003, 12) from which autologous CB arose in the first place. In fact, they are decoupled from any particular biotechnological or clinical appropriation of CB’s molecular properties. While the latter, “over time, move through cycles of legitimation and delegitimation” (Brown 2003, 12), CB as a cryofact continues to exist and engenders CB banks as economic actors that need the capacity to sustain its optionality by staging and participating in interactions that mobilize expectations—be it even humble ones. Its presence demands a kind of legitimation that is not cyclical or volatile but ongoing. Thus, it is not enough for those involved in CB banking to simply adjust and react to what is or is not being hyped “out there.” Instead of coming to terms with “‘communities of promise’ fall[ing] apart” (Brown 2003, 6, emphasis added), these actors engage in building communities *beyond* and *after* promise. It is no longer “future abstractions” that “structur[e] and organi[ze] relationships” (Brown 2003, 18) around CB banking, but the need to maintain any form of expectations and legitimize the existence of CB as a cryofact today.

“Cryofacts *keep* options of becoming” (Friedrich 2020, 339, emphasis in original) only as long as someone is interested in exploring their potentiality in the present. Hence, those who create and curate CB collections seek to keep the scrutiny for “potential future purposes” (Friedrich 2020, 340) going. In doing so, they do not enact future imaginaries but a prolongation of the present. In this sense, creating and curating CB collections means promoting continuity instead of change: establishing arenas, generating recurring research funds, nurturing scholarly reputations, approaching clinicians and transplant centers, and continuing industry-research collaborations. By mediating such developments, which are humdrum enough to prevent the emergence of a future (likely irreversible failure) different from the present (non-failure), cryofacts can turn into agents that perpetuate business as usual in and around the life sciences. Thus, the yield of optionality is not the only form cryovalue may assume. Cryovalue can also be the tenacious yield of social and economic capital—social networks and steady flows of money and resources—beyond success and after promise.

Cryo-arrangements as Assets

Private CB banks can be considered infrastructure-rentiers (see Christophers 2020). They assemble a socio-technical banking infrastructure (Williams 2018) and use it as an asset (Hauskeller and Beltrame 2016b). The latter generates revenue in the shape of rent payments: future parents pay a fee to make use of this infrastructural arrangement for processing and storing their children’s CB. They do not only purchase a spot in a rack in a liquid nitrogen tank. They also pay for their CB unit to be channeled through time-efficient logistical relations, thoroughly checked, processed in carefully maintained lab facilities, and integrated into a secure documentation system.

Public CB banks assemble the same kind of manufacturing and storage infrastructure as their for-profit counterparts, if not a more sophisticated one. Regardless, public CB banks are not related to rentier capitalism. On the contrary: allogeneic CB banking actively opposes any proprietary logics. It “draw[s] upon the common articulation of CB as waste” (Brown 2013, 98) and claims to transform it into a clinically useful gift of solidarity. However, the current circumstances of looming uselessness of donated CB stored in Germany mess with this “system of valuing” (Brown 2013, 98). It is no longer sufficient for keeping the allogeneic CB storage as an economically viable endeavor.

While several public banks have consequently stopped expanding their stock to become mere storage facilities, Z-Bank has managed to avert such failure. Sustaining active operations requires devoting efforts to maintaining expectations and constructing value. As Williams (2015) and Beltrame (2020a, 2020b) have discussed with regard to public CB banks in the UK and Italy, respectively, such practices and attempts may focus on reassembling banking practices to push for the circulation of rare and sought-after CB samples or new CB-derived products. However, in the case of the German Z-Bank, these efforts do not have much to do with valuing or valorizing CB itself. Instead, they revolve around the socio-technical arrangement in which CB is integrated and which makes it valuable in the first place. This includes a rare set of logistical relations, contractual agreements with specialized service providers, and highly specific hardware. It also comprises distinct skills: reading freezing curves, rhythmically shaking just-thawed blood samples, and recognizing inconsistencies in vitality reports comparing pre- and post-cryopreservation parameters. Moreover, Z-Bank's documentation and transaction routines are interlinked with both global and national networks that order and coordinate stem cell donations. The resulting arrangement is unique and difficult to reproduce (Birch and Muniesa 2020, 6); it may not be of value for much, but it is certainly suitable for the handling of cryopreserved stem cells. Just as private CB banks have been doing all along, Z-Bank has succeeded in turning this arrangement into an asset. Yet it did not pursue this in the same way as its commercial equivalents: it did not seek to generate rent payments by "going hybrid" and beginning to store autologous CB units. Rather, it is enacting its cryopreservational arrangement as an asset by using it to attract funding for the making of a new cryofact.¹⁵

Using a well-coordinated cryo-arrangement to diversify the range of types of cryopreserved material is not a rare or unusual idea. Some cryobanks explicitly specialize in renting their infrastructural services to diverse customers with diverse purposes. In addition, private CB banks may cherish and cultivate the ambition to make use of their facilities and expertise for storing additional types of cryofacts. An interviewee from Y-Bank noted:

We are good at cryopreservation. It is the case. We do have the infrastructure, and then, of course, other business areas lend themselves for activities. [...] Not that there is any completed product development or anything like that, but certainly it is something you can at least think about. It could be classical biobanks with tumor samples or something like that. The business

opportunities that are actually still there for us are quite big. (Y-Bank employee, March 6, 2020)

In addition to curating relations that sustain CB's optionality and potentiality, as described in the previous section, Y-Bank is also interested in further realizing the potential value of its cryo-arrangement. In fact, this was an asset from the very beginning. Given that the potentiality of autologous CB is increasingly failing to spark significant interest, the asset condition of Y-Bank's cryo-arrangement is becoming endangered. This particular state of non-failure, in turn, mainly attracts investors concerned with securing the viability of private banks as rentiers by further facilitating market concentration (see Christophers 2020, xxiv) rather than sponsoring complementary business models. Thus, Y-Bank has no choice but to finance its ambitions through regular rent payments: "With the umbilical cord business, which is in the black, we are financing, cross-financing that entire research and that entire product development" (Y-Bank employee, March 6, 2020).

Z-Bank's similarly precarious state of non-failure, on the other hand, is very differently conditioned. It never engaged in rentiership (see Birch 2020) and is unaffected by the logics of financial valuation and capital investment. At the same time, there is hardly anything that can be done to enhance the use value of its CB collection. Its looming uselessness resulted from factors beyond Z-Bank's control: the geography of CB transplantations in general and the lack of clinical routine in Germany in particular. Hence, averting failure induces the need to reutilize resources beyond the biological material itself. As one of its managing directors told me, the public CB bank was about to be shut down when he and his fellow CEO decided to act upon their idea to use the banking infrastructure they had established to acquire and store another type of biomedical cryofacts. Different from CB, so their line of reasoning went, those other cryofacts would be highly demanded by transplantation centers and thus make the entire organization profitable again. Subsequently, Z-Bank's representatives convinced the board of its umbrella organization that its cryo-arrangement was an asset and that it would be valuable for public health and bring in revenue if only it could be used for a purpose beyond CB banking. With no private investors in the picture, they pursued what Muniesa et al. (2017, 115) call capitalization of public interest. Drawing on the example of a public hospital, Muniesa and colleagues observe that "[i]n order to become an object of capitalization, something just needs to be in search of funding" (Muniesa et al. 2017, 111). In fact, starting from a

rather hopeless situation, Z-Bank actually managed to generate a considerable flow of funding resources.

At the time of my research stay, the search was over. The phase of “asset conditioning” (Muniesa et al. 2017, 116), namely the “preparatory work” (Muniesa et al. 2017) that is done to present the components of a public interest organization as an asset, had already succeeded. When I came to Z-Bank, the funding was there and being spent on new lab facilities, new hard- and software, new staff, and good manufacturing practice (GMP) consultancy services. There were no longer any signs of “agony,” but rather high stress-levels, overtime hours, and a multitude of strategy meetings. Failure had been averted, and the risky-yet-hopeful state of non-failure prolonged.

The case of Z-Bank as juxtaposed with that of Y-Bank points to the contingency of value construction. It shows that harnessing its infrastructure as an asset may not be an option for a genuine rentier firm, whereas it becomes the only thinkable path to take for a nonprofit organization. *How* the value of *what* is constructed is highly dependent on the particular situation in which an enterprise finds itself, and on the factors that constitute that situation. What is turned into the object of valorization practices is not necessarily the tissue that is stored, its vitality, or its potential future utilizations (see Morrison 2017). In the field of cryobanking, the construction of value may instead crystallize around elements and relations that enable the transformation “from detritus to ‘clinical gold’” (Waldby and Mitchell 2006, 114). Thus, the fieldwork material presented here supports Birch’s (2017) call for STS scholars to begin the analysis of value construction in bioeconomies by looking at what happens in and around organizations rather than what is done with tissues. Moreover, the extension of “achievements of capitalization and valuation” (Birch 2017, 466) to an entire cryo-arrangement lends weight to my argument for diversifying the notion of cryo-value. Turning arrangements into assets is a prevalent ambition of actors once they have succeeded in assembling them. Studying the circumstances and ways in which operators of cryobanks realize this ambition sheds light on an important, yet largely overlooked driver of both stability and change in contemporary cryoeconomies.

Conclusion

An inquiry into the field of CB banking in Germany presents a liminal state of non-failure. Even though circumstances played out in a way that posed a risk of irreversible failure for both the public and the private CB bank I

studied, they maintained their operations amid a lack of success. Averting failure was a capacity that afforded particular ways of constructing value. These efforts did not revolve around CB's vitality and were not mediated by biotechnologies. Instead, they were conditioned by the peculiar ordering of CB as a cryofact—literally frozen and inseparably intertwined with cryo-arrangements, as well as frozen in time and made to last. These insights support the claim that practices of cryopreservation engender a liminal state (Radin 2017; Lemke 2019), and a temporal zone in which “alternatives are kept open and courses of action can be corrected” (Wolff 2021, 83). In fact, it even gives this claim another twist. Thus, it indicates that the capacity to suspend life does not only engender liminality in temporal and spatial configurations (Lemke 2021). It may also foster liminal manifestations of economic agency—such as the ones that enable Y-Bank and Z-Bank to pursue their activities despite continuously imminent failure.

With regard to the relation between suspension, expectations, and value-making discussed above, the case of CB banking in Germany shows that cryovalues can be construed as a specific, intermediate value form, the result of efforts invested into the maintenance of a future perspective. Its generation and exploitation is enabled by the cryotechnological suspension of the final utilization (or disposal) of biological artifacts. At the same time, cryovalues keep subsequent expectations and value-making practices possible. Hence, this value form legitimizes further suspension and further defers potential failure—even if actual success is far out of sight.

In extending the notion of cryovalue for the analysis of value construction amid the liminal state of non-failure, this paper contributes to discussions on the diversity of valuation and valorization practices in bioeconomies. The case of CB banking shows that the material endurance of cryofacts may bring about a peculiar tenacity when it comes to maintaining their status as “matters of concern.” This tenacity generates value insofar as it facilitates the steady yield of social and economic capital beyond high expectations. Apart from that, the absence of optimism in the field of cryobanking may mess with familiar configurations of value construction. The making of value might be reoriented from the cryofacts themselves toward the socio-technical arrangements in which they are integrated. Valorization practices, in turn, can be decoupled from their conventional “habitats”: assetization may become hard to pursue for rentiers, while being successfully accomplished by public organizations.

This investigation into CB banking in Germany three decades after its emergence finds that contemporary tissue economies are not always

characterized by the straightforward valorization and utilization of biological vitality. An exclusive focus on rapidly developing and hyped branches of the bioeconomy runs the risk of reifying the image of these processes as limitless and impregnable. Cryobanking, on the other hand, is particularly “good to think with” when it comes to studying continuities in and around bioeconomies beyond progressivism. It is assembled to withstand the flux of trends, promises, doubts, and scandals. Tracking how it does so gives a glimpse of how “cryogenic culture” (Friedrich and Höhne 2016) reproduces itself over time. Furthermore, it expands our understanding of what it takes for economic actors to endure under various circumstances—something that seems more topical than ever in the early 2020s. In today’s market economy, promises no longer constitute the most prevalent mode of future orientation. High expectations gave way to the need to go on against all odds.

In pointing out to these themes of inquiry, I am proposing to nurture empirically sensitive accounts of how cryopreservation practices relate to commonplace configurations and conceptualizations of bioeconomies. In addition, I am suggesting that future STS research on cryoeconomies might further explore how these practices not only enact futures but also humbly defer them by fixing, saving, and extending the present (cf. Wolff 2021; Lemke 2021).

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Notes

1. All excerpts from field notes and interview transcripts cited in this paper were translated from the German by the author.
2. See <https://www.researchandmarkets.com/reports/5232567/global-cord-blood-banking-industry-report-2021>, last accessed on January 30, 2022.
3. In particular, the increase in haploidentical stem cell transplantations, with their even lower demand of immunocompatibility and less laborious and costly procurement, has led to a decline of the use of cord blood (Passweg et al. 2017; Dessels, Alessandrini, and Pepper 2018).
4. See <https://share.wmda.info/display/WMDAREG/Database>, last accessed on January 30, 2022.
5. See <https://parentsguidecordblood.org/en/family-banking>, last accessed on January 30, 2022.
6. See <https://statistics.wmda.info/>, last accessed on January 30, 2022.
7. See mandatory offer by the AOC Health GmbH, https://ir.vita34.de/wp-content/uploads/pdf/Vita34_Stellungnahme_Vorstand_und_Aufsichtsrat_Pflichtangebot.pdf, last accessed on May 5, 2022 (translated from the German by the author).
8. Reardon's (2017) book on *The Postgenomic Condition* and Aarden's (2017) study of the closure of the Singapore Tissue Network are notable exceptions. Reardon scrutinizes the aftermath of the failed promises of the Human Genome Project and what researchers, policy makers, and various other actors make of it. Aarden zooms in on the reasons for the definitive failure of a national biomedical repository initiated as a top-down science policy endeavor.
9. See, for example, <https://www.cordblood.com/prepaid-account-terms>, last accessed on January 30, 2022. Even though family banks offer to store CB units for a longer time period than public banks, there is hitherto no scientific evidence for the viability of samples that are older than 23.5 years.
10. However, keeping biological material potentially viable and available for a long time is not an endeavor that is self-evident and successfully accomplished by any CB bank (or any cryobank in general). Rather, various circumstances can undo the viability and availability of cryocollections. Williams's (2018) and Beltrame's (2020b) empirical material, for instance, shows that public banks in UK, Spain, and Italy hardly release any of their older units as the latter no longer meet the current requirements with regard to the "initially collected data"

(Williams 2018, 477) and cell count thresholds. This largely applies to the German Z-Bank as well, but I did see documentation for several cases where transplantation centers requested CB samples older than ten years. Once, I even witnessed such an inquiry firsthand: after receiving a request for an old sample, an employee of Z-Bank called the mother of a donor who had already turned eighteen at that point, and who therefore needed to be contacted personally. Thus, it is not just the cryotechnologically induced time lag but also the fact that the German public bank's large collection is approached as a viable one that sets the stage for the liminal state of non-failure.

11. Another take on liminality as a consequence of “the incommensurability between the promise and capability of medical technologies” is Timmermans and Buchbinder's (2010, 419) study of patients-in-waiting: “people trapped between a state of sickness and health” (p. 409) due to abnormal newborn screening test results that cannot be followed up by further clinical measures. While this US-based study points to patients' liminal subjectivities, my insights suggest that the mismatch between biomedical promises and realities also turns liminality into a crucial experience for economic actors in Germany.
12. CBA newsletter, January 13, 2021.
13. See <https://www.cb-association.org/our-mission>, last accessed on January 30, 2022.
14. Save the Cord Foundation is “dedicated to advancing cord blood education” (<https://www.savethecordfoundation.org/countries.html>, last accessed on January 30, 2022) and hosts the WCBBD, an online conference that serves as a venue for researchers to present their work on CB's clinical utility to healthcare professionals, parents, and students.
15. To keep the organizational identity of Z-Bank undisclosed, I deliberately abstain from elaborating on the exact nature of this cryofact. I can, however, state that its development is heavily dependent on the specific material artifacts, logistical relations, and forms of know-how that add up to Z-Bank's cryo-arrangement.

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