

The Bio-Objectification of Umbilical Cord Blood: Socio-Economic and Epistemic Implications of Biobanking

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Abstract: In the current biomedical literature Umbilical Cord Blood (UCB) is considered a valid source of hematopoietic stem cells for hemopoiesis reconstitution. The acknowledgment of the potential of UCB for transplants prompted the transformation of this human tissue from a discarded human residuum to a valuable life-saving tissue. Drawing on the notion of bio-objectification (Webster 2012), this paper critically investigates the socio-technical process by which this transformation occurred, and explores the two-way interaction between basic biological research and clinical settings in which the therapeutic use of UCB was developed. Secondly, drawing on the notion of biobanks as forms of governing life, this paper analyzes how different institutional arrangements in UCB biobanking produce different routes in UCB bio-objectifications and different economic regimes of UCB exploitation. UCB biobanking thus entails diverging articulations of the relationship between biomedicine and society, and the co-construction of medical technologies, therapeutic applications, subjectivities and social rationalities.

Keywords: umbilical cord blood; biobank; bio-objectification; bioeconomy.

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I. Introduction

Umbilical Cord Blood (UCB) contains stem and progenitor cells capable of restoring haematopoiesis, i.e. the physiological process by which the organism produces blood cells. It is therefore currently used for

transplantations in patients suffering from haematological malignancies, and immunological and metabolic disorders (Navarrete and Contreras 2009). The discovery that UCB contains haematopoietic stem cells (HSCs) dates back to 1974 (Knudtzon 1974). However, the first successful UCB transplant was performed in 1988 on a paediatric patient with Fanconi anaemia, using UCB from a sibling (Gluckman *et al.* 1989).

Nowadays, UCB is considered a valid alternative to bone marrow (BM) transplantation for reconstituting haematopoiesis in both children and adults also in the case of partial histocompatibility (Kurtzberg *et al.* 1996). The graft/host tissue compatibility in human allotransplant is regulated by the human leukocyte antigen (HLA) complex – i.e. the loci of genes encoding the proteins (antigens) responsible for immune reactions and thus also for organ transplant rejections – so that the more the HLA complex of the donor and recipient match, the less the immune system of the recipient will reject the engrafted tissue. Common in BM transplant is graft-versus-host-disease: the lymphocytes (a particular kind of leukocytes or white blood cells) in the engrafted tissue attack the host's body cells because they recognize them as antigenically foreign. Consequently, there must be histocompatibility between the HLA systems of the BM donor and recipient – which makes the search for a compatible donor a difficult and long procedure. Instead, since UCB lymphocytes have a naive immunophenotype (Han *et al.* 1995), there is a low rate of graft-versus-host disease in UCB transplants (Broxmeyer 1995; Wagner *et al.* 1996) permitting transplantation also between partially mismatched donors and recipients (Kurtzberg *et al.* 1996; Wagner *et al.* 1996; Rubinstein *et al.* 1998).

Moreover, the biomedical literature stresses that, while BM registries are databases of potential donors and BM donation requires hospitalization and general or spinal anaesthesia (a painful and risky procedure), UCB repositories store tissues directly available on-demand, collected with little or no risk for the donors, and with a lower incidence of microbial, fungal and virus infections. Thanks to these features, the use of UCB in transplantation has increased over the years. According to Bone Marrow Donor Worldwide (the organization managing the registries of all HSC sources – BM, UCB and peripheral blood), more than 20,000 UCB transplants were reported worldwide from 1989 to 2009, and more than 560,000 UCB units were stored in more than 100 UCB banks (Bone Marrow Donor Worldwide 2013). Therefore, what “was generally regarded, along with the whole placenta and the attached portion of umbilical cord containing it, as a discarded human residuum” (Fernandez 1998, S84), is now considered a valuable life-saving tissue. The term ‘valuable’ is of key importance, because it refers not only to UCB's clinical utility in transplants – or as an epistemic thing (Rheinberger 1997) in oncology, haematology and stem cell research – but also to its economic exploitation and the related societal and ethical issues. UCB used in the clinical setting is not what was once discarded; rather, it is a bio-object (Webster 2012) fabricated in a complex, multilayered network of practices, procedures

and institutions that (non-linearly) links the social world of basic biomedical research with that of clinics and, furthermore, with society at large. The key node of this network is the UCB bank: it is the institutional site in which the bio-objectification of UCB takes place. It therefore makes this tissue available for its “mobility across different socio-technical domains...[and] between different sectors or network of society” (Webster 2012, 3), as well as for economic exploitation. Indeed, there are two main institutional arrangements of UCB biobanking: the worldwide network of national public biobanks – which manage the storage and distribution of this tissue for the public healthcare system – and the private sector, where private companies sell to new and prospective parents the opportunity to store the UCB of a newborn child for future familial use by paying a fee. This entails two different forms of (economic) evaluation of UCB: in the public sector UCB is considered a public resource, which is collected through an act of donation and supplied in a redistributive economy; in the private sector, instead, UCB is regarded as a private biological asset, and UCB banking is advertised and sold to parents as a biological insurance against possible future illnesses in a market economy framework, where individuals negotiate with the emerging biomedical industry on exclusive possession of a corporeal commodity.

By drawing on the notion of bio-objectification (Webster 2012), this paper will first explore how UCB was transformed from a waste material to a valuable life-saving tissue. I shall show how the bio-objectification of UCB took place through a two-way interaction between the bench and the bedside. Secondly, by using the analytical framework developed by Gottweis (2008), which considers biobanking as a form of governing life, I shall analyze how the institutional arrangements of UCB biobanks imply different routes to UCB bio-objectification and are thus connected to diverging articulations of the relation between biomedicine and society. According to Martin *et al.* (2008b, 142), UCB biobanking is a crucial site in which there occurs a co-construction of “new promissory technologies, novel therapeutic applications, and new types of consumers motivated by changing moral imperatives”. This paper analyzes this co-construction in the two opposing institutional arrangements of UCB biobanking, and thus considers the related social implications.

Finally, I shall show how the focus on institutional arrangements allows the notion of bioeconomy to be rethought in more critical terms.

2. Bio-Objectification, Biobanks and the Bioeconomy

Webster (2012) has developed the concept of bio-objectification as a heuristic device to refer to the technoscientific creation of life forms and “technologically enacted vital materiality” (p. 2) in order to take into ac-

count the biotechnological transformation of life and its biological boundaries.

Developments in biotechnologies and the life sciences have moved the control and manipulation of vital processes to the level of their cellular and molecular mechanisms (Waldby 2002): cells, tissues and biological information (such as gene sequences) are disentangled from their corporeal embodiments and transformed into technologies deployed in biomedicine and, in general, in the biotech industry. Webster (2012, 2), indeed, exemplifies bio-objectification, and the biotechnological reformulation of the living, by showing how aborted foetal tissues, previously regarded as waste matter, “can be re-vitalised as source material for stem cell lines”.

This biotechnological reformulation and transformation of biological entities has resulted in new types of “separable, exchangeable and reincorporable body parts” (Rabinow 1999, 95) which flow in international circuits and are exploited for the creation of “biovalue” – i.e. “the yield of vitality produced by the biotechnical reformulation of living processes” (Waldby 2002, 310). A growing body of social science literature has drawn attention to the ways in which the body and its component parts have become a preeminent site of capitalization. Scholars have noted that the biotech field is increasingly “organised as a market” (Birch 2006, 3), and that “the object of bioscience, the practice of bioscience, and the locations of bioscience have all been changing [...] toward more corporate forms and context of research” (Sunder Rajan 2006, 4). In other words, biosciences are not only committed to the production of truth, but are increasingly intertwined with the creation and mobilization of venture capital through the “patenting of cell lines, genes and transgenic organisms” and their transformation into “intellectual property and possible sources of profit” (Waldby 2002, 310).

This literature has explored the growing commercialization of life itself and its socio-cultural implications by extending the work of Michel Foucault. Firstly, it draws on his notion of biopolitics (Foucault 1976), i.e. the practice of governance that brought life itself and its mechanisms into the realm of political calculations and rationalities addressing the biological existence of individuals and populations. Secondly, it explores the intertwining between modern biology and political economy – whereby the “organic becomes the living and the living is that which produces, grows and reproduces” (Foucault 1973, 232) – at the molecular and cellular level. In this sense, terms such as bioeconomy or biocapital have been introduced to highlight how biological entities (organs, tissues, cells, and gene sequences) “are increasingly inserted into projects of product-making and profit-seeking” (Helmreich 2008, 464). Consequently, life has become “productive of economic value...[and] the manipulation of life generates a value accorded to the enhancement of health” (Rose and Novas 2005, 455). This “relocation of wealth in the creative forces of human biological

life” (Cooper 2008, 6) means that “life becomes, literally, annexed within capitalist process of accumulation” (Cooper 2008, 19).

Moving from ‘molar’ level of populations and bodies to cellular and molecular components (Rose 2007) means that the capitalization of life itself and the exploitation of biovalue in the current bioeconomy pass through the bio-objectification of biological entities. UCB represents a paradigmatic example of a bio-object, both because it was transformed from waste to a clinical and epistemic valuable thing, and because it circulates internationally among countries and different social environments (laboratories, hospitals, biotech companies) by virtue of a new medium of technical innovation, namely “biobanks or cord blood banks” (Webster 2012, 3). However, the case of UCB tends to complicate the picture drawn by the literature on bioeconomy. Several scholars define the current bioeconomy as a form of market economy, and they link its birth with the neoliberal turn in national economic policies (Cooper 2008; Birch 2006). The biotech sector organized in a post-Fordist corporate way (Sunder Rajan 2006) is seen as consubstantial with the core neoliberal idea that the human well-being and the social good “will be maximized by maximizing the reach and frequency of market transactions” and by individual entrepreneurial freedoms (Harvey 2005, 3). In this sense, Sunder Rajan (2003, 92) pointed out that, in any institutional arrangement of biomedical research: “it is the very definition of what constitutes market logic that is often most at stake in the strategic articulations of biocapitalism”; and also the relocation of biomedical knowledge and information in the public domain (e.g. in the case of the Human Genome Project) represents “less an attempt to negate market logic as much as it is to redefine the terrain in such a way that ‘market logic’ is dictated by the strategic interests” of corporate actors (Sunder Rajan 2003, 105).

However, the bio-objectification of UCB does not automatically mean its commodification in a market (bio)economy framework, since the system of public UCB biobanks organizes and supports a global redistributive tissue economy in which UCB is considered a public resource. I shall show in what follows that the bio-objectification of UCB takes place within a particular socio-technical infrastructure, namely a biobank, which connects different areas of biomedical research with society. I shall demonstrate that it is the institutional arrangement of biobanking that determines the route of bio-objectification of UCB and thus both its status as a (bio)economic good and the related implications for the articulation between biomedicine and society. In other words, I shall explore how the co-construction of biomedical technologies, therapeutic applications and subjectivities, rationalities and social solidarities varies according to the institutional arrangements of UCB biobanking. The two main arrangements of UCB biobanking (the public system vs. the private commercial sector) entail:

- two opposing main regimes of UCB biovalue exploitation (i.e. a redistributive tissue economy vs. a market bioeconomy);

- different routes in UCB bio-objectification;
- contrasting meanings of UCB as a clinical object and an epistemic thing (Rheinberger 1997);
- opposing forms of social solidarity and obligation.

This analytical framework is thus based on the notion of biobanks as forms of governing life. Put simply, biobanks are collections of human biological materials combined with information (personal, medical, genealogical, etc.) and are thus crucial sites within contemporary biomedical research, since they provide samples and bio-information for genomics (Gottweis and Lauss 2011) and stem cell research (Waldby and Mitchell 2006).

According to Gottweis and Lauss (2011, 62-65): “Biobanks consist of highly complex and multiconnected networks [...] stretching to a variety of nodes such as medical schools, hospitals, and health care provision”. Biobanks are not only techno-epistemic technologies linking several sectors of scientific research and healthcare provision, they are also a sort of socio-technical interface between biomedicine and society. As Gottweis and Petersen pointed out, biobanks:

...constitute a complex process of representing science, bodies, medicine and technology. They are a form of governing life and involve a multitude of actors such as scientists, patients, or industry who actively engage in building, describing and operating biobanks and who contribute to translating particular scientific-technological visions into material practices. They involve the deployment of physical infrastructures, artefacts, machines, tools, instruments and buildings. [...] Biobanks always connect with society, culture, the economy and politics. Biobanks incorporate visions for the future of medicine and healthcare, offer resources to medical research and the pharmaceutical industry and embed images of the patient, the citizen, collective identity and society.

(Gottweis and Petersen 2008, 9)

As a form of governing life, the way in which a biobank restructures “the boundaries between the scientific/technological, the social, the cultural, and the political” (Gottweis 2008, 22) depends on the institutional arrangements in which it operates. Gottweis and Lauss identified three different types of biobanks:

(a) the entrepreneurial biobank model that is often carried out in a public private partnership between a commercially oriented entity and different state institutions; (b) the biosocial model in which patient activist groups promote, fund, and facilitate the creation and operation of a biobank; and (c) the public biobank model in which biobank networks are supported mostly through taxpayers money and nonprofit research funding organizations.

(Gottweis and Lauss 2011, 66)

Each of these types implies a different form of governance: a top-down model in the public biobanks, a bottom-up one in the biosocial and “horizontal exchanges between sellers and buyers, producers and consumers” (Gottweis and Petersen 2008, 8) in the entrepreneurial model based on market logic. This distinction is particularly suitable because UCB biobanking is organized into two main models: the network of public UCB biobanks for allogeneic donation, and the commercial sector of private banks for the autologous or family storage. And, as I shall show in the following sections, the institutional arrangement of UCB biobanking implies different routes to UCB bio-objectification and different ways to articulate the relationship among scientific research, the healthcare system and the market, but also because it exerts effects on the articulations between biomedicine and society.

Therefore, in what follows, first I shall analyze the process of UCB’s transformation from a waste material into a valuable tissue. Using the notion of bio-objectification, I shall show how this transformation occurred through a two-way interaction between the social world of basic biological research and that of clinical applications. Second, by drawing on the notion of biobanks as a form of governing life, I shall show how bio-objectification takes place in a particular socio-technical infrastructure whose institutional arrangement defines the articulation of the relation among biomedicine, economy and society. The aim of this paper is to call into question the idea that the modern bioeconomy coincides with the market economy framework and thus means the commodification of life and its cellular and molecular components. On the contrary, I shall show that the economic regime of biovalue exploitation is the outcome of institutional arrangements created by the actors involved, and that these arrangements have implications for the way in which a society is organized.

The paper is based on discourse analysis carried out on articles published in scientific journals – retrieved in PubMed by searching for ‘Placental and Cord Blood banking’ – and on documents produced by bioethics and medical professional bodies (American Academy of Pediatrics 1999; Royal College of Obstetricians and Gynaecologists 2006; European Group on Ethics in Science and New Technologies 2004; Committee on Obstetric Practice 2008), as well as corporate communications available on the websites of private UCB banking companies. Scientific papers retrieved in PubMed were subsequently selected according to various criteria. The historical analysis of the development of UCB bio-objectification was carried out on the basis of review articles (e.g. Gluckman 2009; Navarrete and Contreras 2009) and therefore considered milestone papers in the evolution of UCB clinical application and UCB-derived stem cell science – retrieved by analyzing bibliographic references. Another set of articles included in the analysis dealt with the establishment of UCB banks and the development of techniques for storing and processing UCB.

Finally, articles concerning ethical issues in UCB biobanking and the debate between public and private UCB banks were collected. In this way, a corpus of 108 papers published in the period 1974-2009 (i.e. from the discovery of the presence of HSC in UCB to the 20th anniversary of the first UCB transplant) was analysed through qualitative discourse analysis aimed at detecting both the construction of UCB-derived stem cells as clinical and epistemic objects and economic goods, and the production of social entities and relations. This approach recovers the constitutive function of discourse – as practice that forms the objects of which it speaks (Foucault 1972, 64) – and is thus constitutive of social identities, social relations and systems of knowledge and belief (Fairclough 1992). But it is less focused on the (re)production of power relations, dominance, ideology and hegemony within discursive practices as in critical discourse analysis (Fairclough 1995; van Dijk 1993), and more on the construction of the image and the role of individuals as citizens and/or consumers in the regimes of economic relations and biopolitics models embedded in the various institutional arrangements of UCB biobanking. This analytical approach was also applied to the analysis of documents produced by bioethics and medical professional bodies, and to the corporate communications of private UCB banking companies retrieved on the Internet by searching for umbilical cord blood banking companies. Analyzing corporate communications and websites was necessary because scientific papers and the documents of medical professional bodies tend to be biased against private biobanking. Following social science analysis of UCB biobanking (Martin *et al.* 2008b; Brown and Kraft 2006) and articles dealing with the controversy between public and private UCB biobanks, I selected the most cited and largest private companies and then analysed their advertising and communications.

3. The Bio-Objectification of UCB from Bedside to Bench

The umbilical cord as a site of haemopoiesis was discovered in the 1970s by Knudtzon (1974), who detected colony-forming cells in human UCB. Unclear at that time was both the nature of these cells and their function, to the point that Knudtzon wrote that “they might merely represent an escape from the bone marrow into the circulation” (Knudtzon 1974, 360). Reported in 1982 was the “identification of a unique class of human hemopoietic colony-forming cells with extensive ability to generate progenitors for secondary colonies” (Nakahata and Ogawa 1982, 1324). However, confirmation that UCB is an effective provider of HSC for haematopoietic reconstitution came only in 1988, when a team led by Eliane Gluckman transplanted UCB into a child in order to cure Fanconi anaemia (Gluckman *et al.* 1989). Interestingly, the laboratory-based confirmation that UCB contains HSCs well within the range of BM stem cells

“that have been associated with successful autologous and major histocompatibility complex-matched allogeneic bone marrow transplantation” (Broxmeyer *et al.* 1989, 3830) was forthcoming only one year later. Indeed, Smith and Thomson recounted the story of UCB science and clinical application in these terms:

The study of umbilical cord blood began in 1982, when discussions between Broxmeyer and Boyse led to laboratory experiments that suggested that umbilical cord blood contained hematopoietic stem cells that might be suitable for transplantation [...] This laboratory-based research led to the collection and banking at Indiana University in Indianapolis of cord blood from the siblings of children who were in need of transplantation. Gluckman *et al* in Paris were the first to use a sibling cord blood unit that had been banked by Broxmeyer at Indiana University to transplant a child with Fanconi anemia.

(Smith and Thomson 2000, 127-8)

Similarly, Gluckman (2009) described the clinical application of UCB as the outcome of the collaboration between the laboratory researches of Broxmeyer and her clinical work. The interesting features of this narrative are: (a) the intertwining between laboratory-based research and the clinical setting, and (b) the central role played by the banking of UCB.

The first point testifies to how the clinical application of UCB did not follow the linear model of translational medicine – which postulates a one-way flow from the bench to the bedside – but a two-way interaction between basic biological research and medicine, as described by Keating and Cambrosio (2001) in their study on cytogenetics. In several respects, the history of UCB science and clinical application resembles that of BM, where the first clinical trial was carried out in 1957 before the development of the biological knowledge of HSC (i.e. prior to developing knowledge on the identity of HSC, techniques for its enumeration, and its functioning mechanism). Both BM and UCB clinical applications were developed in a “regime of hope” which proceeded “on the basis of speculative potential therapeutic efficacy, even in the absence of a clear demonstration of underlying principles” (Martin *et al.* 2008a, 32). Authors pointed out that the development of BM transplantation was “characterized by a clinically driven shift from the imagined possibilities of the clinic back into exploratory fundamental research” (Martin *et al.* 2008a, 33). Similarly, in the case of UCB, it was successes in transplantation that prompted the basic research on the features of stem cells contained in it. The clinical application of UCB transplant ran in parallel with laboratory-based research on UCB-derived stem cells. During the 1990s, in fact, clinical applications of UCB transplants were carried out notwithstanding the scant reliability of quantitative assays for HSCs in humans (Gluckman 1996). For example, Broxmeyer *et al.* (1992, 4112) maintained that “the numbers of human repopulating cells cannot yet be calculated”. Still to-

day, the suggested minimum quantity of UCB stored is empirically established – it is recommended to store only the largest units of more than 70ml in order to have at least $\geq 2 \times 10^5$ CD34+ cells/kg – even if the optimal cell count and the relation between CD34+ cells and successful engraftment is still not known (Gluckman 2009, 623). CD34+ cells are cells expressing CD34 cell surface protein, which mediates the attachment of stem cells to stromal cells and thus permits haematopoiesis. The CD34 surface marker is thus considered a marker for HSCs, and the assay of CD34+ cells is used to estimate the number of HSCs in a given sample.

However, as Martin *et al.* (2008a, 33) have shown, the identity of HSCs in terms of CD34 surface makers is contested within the bench community, but it is stabilized in practice in clinical protocols (see also Brown *et al.* 2006, 338). In other words, this is another example of the non-linearity between the bench and the bedside in the clinical application of UCB-derived stem cells.

In general, the history of UCB application shows a two-way flow from the bedside to the bench. Indeed, while clinical haematologists transplanted UCB – and demonstrated the therapeutic efficacy of UCB transplant also in HLA mismatching settings (Kurtzberg *et al.* 1996; Rubinstein *et al.* 1998; Wagner *et al.* 1996) – experimental hematologists were showing that compared with BM, UCB contains a more primitive cell population that has more *in vitro* and *in vivo* proliferative potential (Hao *et al.* 1995). Similarly, while clinicians successfully used UCB stored in biobanks, laboratory scientists were developing techniques to reduce the volume of stored UCB units while avoiding the loss of viable HSCs and the use of toxic cryo-preservants (Rubinstein *et al.* 1995; Denning-Kendall *et al.* 1996). More interestingly, the shift of UCB transplant from a “investigational” procedure (American Academy of Pediatrics 1999, 117) to a routine clinical practice (Gluckman 2009) was prompted principally by the publication of statistical analyses on the outcomes of transplant (Rubinstein *et al.* 1998; Eapen *et al.* 2007) and by reviews of follow-up studies (Navarrete and Contreras 2009). This two-way relationship between the bench and the bedside was made possible by a peculiar institutional setting: the university hospital or the close association and proximity between clinical and research institutions. As in the case of BM transplant (Martin *et al.* 2008a), such proximity fostered collaboration between clinicians and scientists and created an international epistemic community of both UCB practitioners and UCB stem cell scientists.

The second point of the narrative quoted above refers to the role of biobanks. In fact, the development of both UCB transplant and UCB stem cell science would not have been possible without the establishment of UCB biobanks. Indeed, in order to be available for both transplantation and experimentation, UCB should be collected, tested, processed, preserved and distributed. The first UCB biobanks were set up in universities and public hospitals (Armitage *et al.* 1999; Lazzari *et al.* 1996; Rubinstein *et al.* 1994), and it was in these infrastructures that knowledge on

UCB stem cells and technologies to improve its clinical use and preservation were developed. Therefore, UCB biobanks are both crucial nodes in the network linking institutions (laboratories, universities, research centres, hospitals and health care providers) and the sites in which the complex and heterogeneous web of knowledge, expertise, devices, technologies and biochemical substances coalesces in the process of UCB bio-objectification. The bio-objectification of UCB takes place mainly in UCB biobanks through a process termed UCB biobanking, that is, the set of “processing, testing, cryopreservation, storage, listing, search, selection, reservation, release, and distribution of cord blood units” (NetCord-FACT 2013, 8), since a UCB unit “is the end-product of a series of processes” (NetCord-FACT 2013, 58).

The bio-objectification of UCB starts with the process of collection at the moment of delivery, thanks to an articulation with changes in birthing practices. As Brown (2013) has illustrated, from the late 1960s onwards, obstetric and midwifery manuals and guidelines recommended umbilical cord clamping immediately after the delivery in order to reduce maternal post-partum haemorrhages. This means that the blood in the umbilical cord and placenta is not transferred to the newborn, and thus becomes available to collection, since it has been demonstrated that minimizing the time between infant delivery and cord clamping increases the volume of UCB, and thus of HSCs (Donaldson *et al.* 1999). Moreover, obstetricians or gynaecologists must obtain informed consent from the prospective mothers, and they must also generate a medical record regarding the pregnancy and the medical history of the mother and her family. This is a first step in the process of “informationization” (Gottweis 2008, 27) by which the biological is transformed into information inserted in a computerized database. Similarly, after the umbilical cord has been clamped, the blood contained in it should be drained by gravity (and exploiting placenta pulsation), using a sterilized needle and a catheter, and then gathered in a blood collection bag containing an anticoagulant (NetCord-FACT 2013). Therefore, collecting UCB entails both an articulation of biomedical practices and a network of technologies, devices and substances. In other words, what is sent to a UCB biobank is a tissue partially informationalized and already processed.

The second step of UCB bio-objectification is carried out at a UCB biobank – or a set of UCB processing facilities linked to the biobank – and entails analysis of the UCB units (tests for genetic diseases and microbial contamination, cell count and cell viability assays, and HLA typing), and other UCB processing procedures: volume reduction and cryopreservation. Both procedures involve the use of devices and biochemical substances: centrifuges, Hydroxyethyl Starch to separate HSCs from red cells and plasma, Dimethyl Sulfoxide as cryo-protectant, freezing bags, metal canisters and freezers with a monitoring system (NetCord-FACT 2013). When processed UCB units are stored in a cryopreservation de-

vice, the entire documentation, comprising both biological and technical information, is inserted into a database through a validated system.

The UCB as the end-product of this socio-technical network of processes is something very different from what was once discarded; it is now a biotechnologically manipulated thing available both for clinical application and for biomedical research. In a biobank, UCB has two different ontological statuses: 1) as a processed tissue which is stored in a specific place (a freezer); 2) as a record of medical information inserted in a database which makes it accessible to international electronic search systems (like the international Bone Marrow registry). It thus flows worldwide in a transnational network of computer databases; and when it is identified as suitable for a transplant, also the tissue can flow transnationally in a network of UCB banks, hospitals and transplant centres.

It is worth noting that after the transplantation, the informational ontological status of UCB does not cease existing; not only because the documentation must be conserved, but also because now generated is a new medical record regarding the process of engraftment and the follow-up on the transplant procedure. Again, the UCB unit continues to exist with a double status: as an engrafted tissue in the recipient (in which regenerates haematopoiesis), and as a medical record regarding the transplant and the process of engraftment registered in the biobank's database and thus available to the scientific literature on the outcomes of cord blood transplantations. The bio-objectified UCB is thus an immortal entity.

4. Constructing Communities in the Public UCB Biobanking System

The general process of UCB bio-objectification transforms what was once a discarded material into an usable object, but it does not define the form of its exploitation and valuation. This depends on the institutional arrangement in which the UCB biobanking takes place. The UCB biobank is thus the key node in a network connecting hospitals (where UCB is collected) and universities and transplant centres (where UCB is used as an epistemic and clinical object), and it is also the main site of UCB bio-objectification. However, the institutional arrangement of UCB biobanking determines the specific route to UCB bio-objectification and thus the form of the co-construction of this medical technology and subjectivities and social rationalities.

After the first successful UCB transplantation, researchers and clinicians started to establish biobanks to store UCB units. The first public UCB biobank was set up in New York in 1991 (Rubinstein *et al.* 1994), and at the beginning of the 1990s others were established in Paris (Gluckman *et al.* 1993), London (Armitage *et al.* 1999), Milan (Lazzari *et al.* 1996) and in other Western countries. From the outset, UCB practi-

tioners highlighted the need for forms of international cooperation and coordination among biobanks and clinicians and researchers in the field of UCB transplantation and HSC science. The Eurocord group, an organization aimed at promoting cooperation and developing standards in the field of UCB science, banking and clinical application (Gluckman 1996) established the International NetCord Foundation, a non-profit association of UCB banks which has nearly 35 member banks and registries representing about 51% of the global supply of publicly banked cord blood (NetCord 2013). NetCord manages an integrated database that connects multiple UCB banks registries worldwide. But it operates also for the creation of standards and accreditation criteria for UCB biobanks: together with the US Foundation for the Accreditation of Cellular Therapy (FACT) it publishes a manual defining standards for UCB collection, processing, testing and banking (NetCord-FACT 2013). In this way, along with national and international biobanks' regulations, NetCord and FACT have created an international accreditation system, and thus a set of standards, which applies to UCB biobanks (both public and private) participating in this network. In general, the public UCB biobanking system is organized as an international network (Brown *et al.* 2011), and it is sustained by an institutional architecture consisting of medical professional and governmental organizations.

Within this institutional arrangement, UCB is bio-objectified in such a way that UCB “has gained new status as a natural resource” (Annas 1999, 1521); UCB practitioners, indeed, consider UCB to be a human tissue, so that they apply the rule that “no part of the human body should be commercialized and that donation of organs or cells should be free and anonymous” (Gluckman *et al.* 1996, 108). Defining UCB as a public resource supplied and managed in a redistributive economy framework, means that UCB donation is regarded “as a rare and praiseworthy example of altruism” (Annas 1999, 1522) “for the benefit of society” (Pinch 2001, 59). In this sense, UCB donation is framed “as a gift rather than a commodity” and society can claim ownership “to promote the common good” (Sugarman *et al.* 1995, 1784).

The public UCB biobanking system operates according to the logic of Foucauldian bio-politics of the population: it is a form of governing life that disciplines bodies (and their parts), regulates populations (Gottweis 2008) and creates an identification between “the supply of blood, organs and other bodily fragments and the body politic as contained within the limits of the nation-state [which generates] a relationship between the anonymous solidarity that links donor and recipient and the constitution of a subjecthood that is, simultaneously, biological and national” (Santoro 2009, 18). As Brown (2013, 98) has summarized, public UCB biobanking “is promoted with reference to a solidaristic moral economy of gift and altruistic participation in imagined community and nationhood”. For example, when the European Commission asked for an opinion on UCB biobanking from the European Group on Ethics in Science and New

Technologies (2004, 18), the latter stated that public UCB banking “implies an act of solidarity or generosity” and “contributes to the social cohesion”, while private companies represent “a more general shift [...] from a health system based on solidarity” which has characterized the European social welfare model. In this way, public UCB biobanking also constructs subjectivities and social rationalities: citizens as part of the body politic are requested to contribute actively to the public good by donating UCB, and a redistributive tissue economy operates to sustain this social solidarity and bond.

The subjectivity of citizens is also constructed in the biomedical and bioethical literature on UCB donation. For example, the American Academy of Pediatrics has criticized the advertising of private UCB biobanks, which promise a biological insurance against possible future illness, because “families may be vulnerable to emotional marketing at the time of birth of a child” (American Academy of Pediatrics 1999, 116). Citizens are defined as vulnerable to the mass media advertising and direct-marketing approach of private companies which, through “dramatic, impassioned language” (Pinch 2001, 56), sell a service based on a unrealistic prospects and on a misleading use of the expression ‘biological insurance’ since the probability that autologously stored UCB will be of use “approaches to zero” (Annas 1999, 1523; Committee on Obstetric Practice 2008). Thus, public UCB practitioners have criticized private biobanking not only because it results in a wastage of resources and damage to public health (Royal College of Obstetricians and Gynaecologists 2006; Perlow 2005), but also because it exploits the vulnerability of prospective parents.

To summarize, in public UCB biobanking, citizens are constructed both as members of the body politic who must participate in the biopolitics of the (national) population for the common good, and as subjects vulnerable to misleading advertising regarding the range of uses of UCB in biomedicine – subjects who must be protected by the state. This framework entails not only the definition of UCB as a public resource for the good of the body politic – and thus a redistributive economy supporting social solidarity – but it more radically affects the ontological and technical status of the bio-objectified UCB.

Martin *et al.* (2008b, 137) have pointed out that public UCB biobanks operate in what they call a “regime of truth”: UCB is stored for use in its current applications, and research on UCB is carried out “on the basis of current present-oriented ‘evidence-based’ support for existing applications” of UCB stem cells. By contrast, private UCB biobanks work in a regime of hope, where the autologous collection is not only aimed at existing applications in oncology and haematology but at the future prospect of regenerative medicine (Brown and Kraft 2006; Martin *et al.* 2008b). It is worth noting that the possible use of UCB-derived stem cells for regenerative medicine is also explored in public research settings – e.g. the study and characterization of mesenchymal stem cells contained

in placenta and umbilical cord tissue, or the possibility to differentiate UCB cells into non-haematopoietic cells for use in organ repair. However, some scholars (Brown and Kraft 2006; Martin *et al.* 2008b) have stressed that public UCB biobanks deal more with the improvement of current UCB applications (e.g. the expansion of HSCs for treating adults as well), while private banks highlight more their possible future use in regenerative medicine. For example, literature reviews of UCB transplantation mention only the current application of UCB-derived stem cells in haematology (e.g. Navarrete and Contreras 2009) while the advertising of private UCB banks or articles explaining the work of research centres linked to private biobanks (e.g. Bardelli 2010) report experiments and clinical trials using UCB-derived stem cells in regenerative medicine.

Hence it seems that there are different expectations in the two institutional settings about the clinical use of UCB-derived stem cells and, accordingly, they are transformed into different epistemic things. Finally, according to Santoro (2009), UCB processing procedures vary between the public and the private sector, and private companies do not perform the quality controls and transformation procedures adopted by public UCB biobanks. Santoro (2009, 16) points out that we find two different bio-objects in the public and private sector.

5. Constructing Citizens as Consumers in the Private UCB Biobanking Sector

Contemporaneously with the establishment of the first public UCB biobanks, also private biobanks were set up in several Western countries (e.g. the Cord Blood Registry in San Bruno, California and ViaCord, Boston). Martin *et al.* (2008b) have counted 112 private UCB banks operating worldwide and which store some 881,000 UCB samples. These biobanks are commercial enterprises which sell the possibility to store UCB for future use by the autologous donor (i.e. the child) or family members. UCB thus acquires a biovalue as a biological asset: it takes the form of economic capital for the private biobank, and of a speculative investment for parents. Accordingly, UCB biobanking is defined by private companies as a “biological insurance” (Wolf 1998, 5) or “a form of property whose value is oriented toward the biological future” (Waldby and Mitchell 2006, 125). By using expressions such as “peace of mind” (Cryo-Save 2013), “store your child’s future” (Smart Cells 2013a) or “put a little something away for a rainy day”, private companies try to induce new and prospective parents to invest in a technology that may, in the future, prove to save the life of family members (Brown and Kraft 2006, 314; Brown *et al.* 2006). As Brown and Kraft have pointed out, the language and metaphors of banking, investment and insurance refer not only to commercialization, but also to aspirational emotions, affectivity, expecta-

tions and future health risks: UCB banking promises to offer “a simultaneously metaphorical and material indemnity against some unspecified, though feared, future disease disaster” (Brown and Kraft 2006, 316).

On the one hand, this future and risk-oriented discourse is clearly linked to the neoliberal form of government that produces individuals who “will govern themselves, master themselves, care for themselves” (Rose 1993, 291-296) by acting through “a kind of privatization of risk management [...] in which the citizen adds to his or her obligations the need to adopt a calculative and prudent personal relations to risk and danger”. In this way, the subject is constructed as a calculative agent who negotiates his/her own health in a market of biological services. This image is mirrored in novel forms of interaction with the field of biomedicine and biomedical research that some authors term ‘biological citizenship’, a new form of activism related to biological and health conditions which denotes the active engagement in biomedicine by formulating life strategies, developing techniques for the everyday management of physiological conditions, or by actively participating in biomedical research (Rose and Novas 2005).

On the other hand, this discourse is built on notions of kinship responsibilities. Parents are encouraged to do something against some potential future loss or the uncertainties of future disease (Brown 2013); in other words, to take care of the future of their family members. Brown and Kraft (2006, 325) thus define autologous UCB preservation as a “techno-moral entry point into an increasingly private linkage between parenting and biomedicine” with a “set of ‘blood ties’, reproductive duties and responsibilities connecting private consumers with biological services”.

The private UCB banking sector is thus organized according to what Gottweis and Lauss (2011) term the ‘entrepreneurial model’, which is based on market logic and operates through exchanges between sellers and consumers. It represents a particular articulation of the relationship between biomedicine and society and a form of governing life based on a neoliberal notion of biopolitics. Accordingly, the private UCB banking sector is characterized as “a neoliberal privatised market where individuals or families make an exclusive claim on a [...] biological asset that remains private property” (Brown *et al.* 2011, 1115; Santoro 2009). As we have seen, in fact, this arrangement of UCB biobanking is built on, and in turn creates, an ideal of a self-governing citizen who manages his/her own health. Moreover, by using a rhetoric of indemnity, insurance and investment, it also creates a particular subjectivity: the individual is no longer a vulnerable member of the body politic (who has to participate in the common good), but a calculative and prudent consumer under an ethical duty to take care of his/her relatives, who maximizes health and well being by negotiating in a free market of biological services. Therefore, private biobanking creates a different articulation of the co-construction of medical technologies and subjectivities and social ration-

ality.

Moreover, it entails, and in turn enables, a different route to UCB bio-objectification.

Firstly, UCB in private biobanking is not a public resource but a private good, even if it is not properly a commodity. As Brown (2013, 99) has highlighted, parents pay a fee to retain proprietary control over an asset diverted away from the globally distributed public UCB exchange systems (see also Brown *et al.* 2011). For what is sold and bought is not the UCB units, but the storage service. As Waldby and Mitchell (2006, 124) have noted, the private UCB account creates a form of possession which excludes the commodity form, since the value of UCB resides in its not being alienated, in its not having an exchange value.

Secondly, this private good or biological asset has a value which resides in the biological future, and more precisely in “the future-oriented promissory value of regenerative medicine [...] embedded largely in future potential rather than present utility” (Martin *et al.* 2008b, 132; Brown 2013; Waldby and Mitchell 2006). Indeed, in their advertising, private UCB biobanks report both the current clinical application of UCB and the experimental setting and clinical trials using UCB for heart, lung and liver diseases (Smart Cells 2013b). Some private biobanks, moreover, operate directly in the field of stem cell research and regenerative medicine (Martin *et al.* 2008b) by promoting and carrying out research on non-hematopoietic stem cells – such as the mesenchymal stem cells – harvested from umbilical cord tissue to repair organs (Bardelli 2010). As mentioned above, UCB in the private sector is thus a different epistemic thing and it is bio-objectified more according to a regime of hope – i.e. the expectations surrounding the future of regenerative medicine – and less according to the regime of truth of established clinical settings in oncology and hematology – in which the public UCB biobanking system operates (Martin *et al.* 2008b). Therefore, in contrast to the public system, the institutional arrangement of the private sector implies a specific route to UCB bio-objectification that defines a different status of UCB, as both a good and an epistemic thing for biomedical research, but also entails a different co-construction of subjectivities and social rationalities.

6. Conclusion

This paper has explored the bio-objectification of UCB as it was transformed from waste material to a valuable life-saving tissue in clinics, and to an epistemic thing in stem cell research. The bio-objectification of UCB has taken place through a two-way interaction between basic biological research and medicine by virtue of a particular institutional arrangement – that of university hospitals – in which different biomedical expertises could cooperate. In this network of institutions and expertises,

a key role is played by biobanks, which are the strategic nodes of interconnection and the material places in which the bio-objectification takes place. Therefore, I have analyzed two opposing articulations of the institutional arrangement of UCB biobanking which give rise to different routes to UCB bio-objectification. These routes are, furthermore, connected to different framings of UCB's status as both a good and an epistemic thing, and therefore to different economic regimes of biovalue exploitation, subjectivities and social rationalities. Indeed, biobanking is a form of governing life. Hence different arrangements in UCB biobanking entail different models of biopolitics.

In the case of the public UCB biobanking system, UCB is bio-objectified as a tissue for its application in established clinical settings (a regime of truth), and it is defined as a public resource managed and exchanged in a redistributive bioeconomy according to a state-led biopolitics of the population, in which the individual body and its component parts are identified with the body politic. Accordingly, citizens are constructed as individuals having responsibilities for the community's good. In this sense, donation is an altruistic act which creates social solidarity and cohesion, and reinforces social bonds. In the case of the private UCB biobanking sector, instead, UCB is bio-objectified as a form of biological insurance, a private corporeal asset, oriented toward the future of regenerative medicine development. It is both a private good and an epistemic thing for the regime of hope of stem cell research. This asset does not have exchange value as a commodity; rather, what is sold and bought is the possibility to store it as an indemnity against possible future risks. In fact, what is exchanged in the market is a biological service, not a material good. In this sense, private biobanking operates according to a neoliberal biopolitics in which the citizen is constructed as a responsible, calculative and prudent consumer under an ethical duty to take care of his/her relatives, and who negotiates the health of his/her relatives in a market of biomedical services.

The case of UCB bio-objectification opens an interesting window on the contemporary bioeconomy because it sheds light on diverging articulations of the process of exploiting biovalue. It shows how different institutional arrangements can give rise to different forms of bioeconomy (a market vs. a redistributive economy) and, thus, how different routes to bio-objectification entail opposing models of governing life, which, in their turn, imply the construction of diverging subjectivities and social solidarities and bonds. The case of UCB invites us to explore how the market logic in the political economy of life itself is not an inevitability, but rather the outcome of strategic articulations of the actors involved and of the institutional arrangements in which both bio-objectification and biovalue exploitation take place. In this sense, an economic regime of biovalue exploitation is not only socially and politically shaping, but it is also socially and politically shaped. Instead of considering bioeconomy in its neoliberal market framework as a given, we should investigate the in-

stitutional arrangements, power relations, and agency of the collective and institutional actors shaping the emerging economic regimes of biovalue exploitation.

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