5

Population Biobanks' Governance: A Case Study of Knowledge Commons

Andrea Boggio

The term "biobank" refers to a variety of research infrastructures that involve the collection, storage, and analysis of genetics samples that are linked to data regarding the health and lifestyle of the sample sources. Population biobanks are a particular type of biobank as they focus primarily on a population or a large subset of a population and permit research to explore the relationship between genes, environment, and lifestyle on large cohorts. Population biobanks are also an emerging knowledge commons: they are infrastructures made of pooled resources that researchers from all over the world can access for uses that are not predetermined by the biobank managers. In this chapter, I discuss how population biobanks are increasingly managed as commons, what role biobank governance experts have played in overcoming regulatory obstacles and in managing negative externalities, and areas of governance that need further refinement for population biobanks to be fully managed as commons. The case study traces the history of biobanking governance and discusses the process that has led to a convergence toward a commons approach. My analysis draws from the literature on biobank governance and on knowledge commons theory as well as my experience as a scholar who participated in the governance shift toward a commons approach to biobank governance. This case study provides important lessons to scholars of knowledge commons as it shows the importance of expertise in managing pooled resources as commons.

5.1 DEFINING POPULATION BIOBANKS

A biobank is "an organized collection of human biological material and associated information stored for one or more research purposes" (Public Population Project in Genomics and Society (P3G), 27). The classes of biobanks that are included in this definition are heterogeneous in terms of scope, geographical presence, cohort characteristics, size, scientific aims, nature of the samples collected, duration, type

Andrea Boggio is Professor of Legal Studies, Bryant University, Smithfield, Rhode Island.

https://doi.org/10.1017/9781316544587.006 Published online by Cambridge University Press

of data, level of security, institutional setting, and funding (Dove et al. 2012). The term is of relatively recent usage. For years, various terms, such as genetic databases or tissues and data collections, were used to refer to projects combining genotype and phenotype data. Its usage has been increasingly prevalent from the mid-2000s.

The term "biobank" is now widely used as umbrella concept to refer to diverse structural arrangements with a research common core. In this chapter, I focus my attention primarily on population biobanks, which are "collections of biological material and the associated data and information stored in an organized system for a population or a large subset of a population" (Organisation for Economic Co-operation and Development 2006). UK Biobank constitutes a textbook example of a population biobank. This biobank was established in the mid-2000s with public funds, which have been supplemented with private money from organizations such as the British Heart Foundation and Diabetes UK. The vision of the promoters of UK Biobank was to establish a long-term research infrastructure for the study of the interactions between genes, environment, and health. To achieve this goal, the biobank has collected samples (blood, urine, and saliva) and detailed information from half a million UK residents between the ages of 40 and 69 from across the UK recruited between 2006 and 2010 (Sudlow et al. 2015). Genotypic data are linked to data on blood pressure, lung function and grip strength, height, weight and body mass, arterial stiffness, vision, hearing, family history of common diseases, bone density, diet, and fitness. At the recruitment stage, participants were asked to consent to their samples and data being used in "a diverse range of research intended to improve the prevention, diagnosis and treatment of illness, and the promotion of health throughout society" (UK Biobank 2006). UK Biobank has conducted its own research project as a nonprofit charity under the direction of a principal investigator who has management authority both as a scientist and as the director of the Coordinating Centre. Since its inception, researchers from all over the world have been able to access the collection since 2012 (Sudlow et al. 2015). Between 2012 and 2014, "over 1,000 researchers successfully registered, and over 200 applications were submitted" (Sudlow et al. 2015).

UK Biobanks is not the only population biobank in operation. Population biobanks have been established throughout the world since the mid-2000s. The Public Population Project in Genomics (P3G), which is an international consortium that is a leader in genomics and biobanking governance, provides an excellent source to map out which population biobanks are active and where they are located. In fact, P3G maintains various "catalogues" providing information on population projects in genomics. The Study Catalogue (www.p3gobservatory.org/studylist.htm) lists 164 population-based studies in genomics. All of them are infrastructures that collect samples and/or data. The Network Catalogue (www.p3gobservatory.org/network/populationBased.htm) is composed of 16 networks involving two or more institutions conducting population-based studies in

genomics. Some are based in a country (Canada, Italy, Norway, Latvia, Finland, Singapore, Sweden); some are regional (Danube River and in neighboring regions); some are international.

5.2 POPULATION BIOBANKS AND KNOWLEDGE COMMONS

This chapter focuses on population biobanks, even though some of the insights are applicable to other types of biobanks. This choice is based on the fact that population biobanks are increasingly managed as commons – and more so than other kinds of biobanks – and, as a result, are more relevant to the study of knowledge commons. Knowledge commons, which includes commons involving informational, scientific, cultural, and other types of intellectual resources, refers to governance regimes for shared resources in the cultural environment (Frischmann 2012; Frischmann et al. 2014a). Scholarly interest in knowledge commons stems from the study of commons involving natural resources that are shared by a group of people and are subject to the dilemmas of collective action (Ostrom 1990, 2002) and on the preliminary work by Ostrom and Hess in the area of knowledge commons (Hess 2012; Hess and Ostrom 2007). The two authors conceptualized these commons as possessing three dimensions – information facilities (in which information is stored), artifacts (the physical units that flow from a facility), and ideas (nonphysical units that flow from artifacts and the content of artifacts).

Building on these insights, scholars of knowledge commons have developed an analytical framework that applies some of the ideas developed for the governance of natural resources to cultural resources. The framework deploys multiple variables that are specific to a particular commons, including attribute variables (resources, community members, and goals and objective of the commons), governance variables (mechanisms, decision makers, institutions, formal and informal norms), and variables associated with patterns of use and outcomes (benefits, costs, and risk) (Frischmann 2013; Frischmann et al. 2014a). A commons management approach for resources entails some degree of openness of the resources to contributors and users on nondiscriminatory terms and some degree of freedom that users enjoy when accessing the resource. They must be able to use it "as they see fit" (Frischmann 2012: 92). A commons approach does not imply the right to use the resource for free or without any terms and conditions. What it implies is that the choices that users make upon accessing the resource are not predetermined or prioritized by the resource managers (Frischmann 2012). Because of their characteristics, population biobanks can be construed as knowledge commons. They involve a set of resources that are *pooled* – stored samples and associated data – *with a purpose* – the goal of population biobanks is to produce valuable data and knowledge by enabling genomics research that advances our understanding of how genes and environment affect health – that

can be best achieved when the resource is *shared by a community of users* – researchers in the biomedical field.[1]

Population biobanks also share another feature with knowledge commons: they contribute to solving social dilemmas of three kinds: overcoming financial barriers that are insurmountable for the average researcher, balancing access to the resources with the risk of depletion and pollution, and management of negative externalities. The first dilemma is one of cost. The costs involved with setting up and maintaining a biobank are substantial and unaffordable for the average researcher or institution. Population biobanks are vehicles to pool resources that researchers would not have at their disposal if they were acting individually. In the absence of biobanks, the collective loss would be tangible because it would reduce opportunities for conducting genomics research and producing genomics knowledge. Population biobanks solve the dilemma by pooling sufficient resources and allowing researchers to use the infrastructure on a discriminatory basis.

The second dilemma is one of depletion and pollution of the resources through use. The dilemma stems from the fact that biobanks are only valuable if they are accessed and used, but access and use can diminish or pollute the resource and create negative externalities in the form of risk of harm (invasion of privacy, discrimination, social stigma, or distress) for those who have consented to the storage of their samples and personal data. Depletion is inherent to the nature of some of the collected resources. Research with human tissue, for example, naturally consumes a certain quantity of the resource whenever it is studied. To perform certain analyses, researchers must have access to tissue, cut a slice out, and analyze in their lab. This is a classic example of a social dilemma: the resource is diminished as a result of being used. More use means increasing social value but also diminishing the resource. With regard to pollution, data is valuable if it can be read and used by the scientific community. If there were a risk that a researcher could, perhaps negligently, destroy some data, change the format, add irrelevant and confusing information, and so forth, the social utility of the resource would be diminished. To solve this dilemma, biobanks are set up with governance bodies and policies that require them to act in the public interest as stewards of the resource. Biobanks thus only grant access to tissue and data if users agree to use the resources in a way that does not compromise them for future uses. To this end, biobanks monitor access and use by ensuring that tissue is used in research that is scientifically sound and in the public interest.

Finally, the third dilemma concerns the negative externalities associated with the use (and misuse) of the samples and data stored at a biobank. Access to these resources could harm those who agreed to tissue and personal information being

[1] According to Hess and Ostrom (2003), data and knowledge can be respectively labeled as artifacts and ideas. In the case of population biobanks, artifacts consist of the physical stream of data that flow from the research conducted using the biobank and include articles, research notes, books, databases, computer files, and webpages. Ideas are the nonphysical flow units that collectively constitute the body of genomics knowledge.

stored. Third parties could use genotypic and phenotypic data as well as other personal information to identify the person linked to this data and engage in harmful behavior against that person. Further, those who access a biobank could make incidental discoveries (regarding predisposition to disease, paternity, and similar situations) that could have negative consequences for participants or family members. To solve this dilemma, biobanks also act as trusted protectors of the interests of participants, being set up in a way that ensures that the resource is used without compromising the interests of the donors. This is done through record de-identification, data encryption, and other security measures.

To resolve these social dilemmas, biobanks have been increasingly managed as stewards of samples and data, acting as trusted mediators between the interests of participants and the public interest in pursuing research and arbiters among scientists competing for the use of the resource. The commons approach naturally constitutes a governance framework that ensures that the social value of the resource is maximized while the types of social dilemmas that I describe are solved.

5.3 POPULATION BIOBANKS ARE INCREASINGLY MANAGED AS KNOWLEDGE COMMONS

According to Frischmann (2012), an infrastructure is managed as a commons if it grants access to the resource to a certain community of users on a nondiscriminatory basis, that is, independently from the identity of the user and for a wide range of uses that are not predetermined by the infrastructure managers. Normatively, nondiscriminatory sharing is a desirable management principle as infrastructure uses are likely to generate positive externalities or "spillovers" (Frischmann and Lemley 2007) consisting of artifacts and ideas that are produced by the very fact that the infrastructure is constantly used in novel and creative ways. When applied to population biobanks, nondiscriminatory sharing entails making the research platform accessible by members of the scientific community with regard to their identity and for a wide variety of researches.

A review of current access and use policies of population biobanks reveals that nondiscriminatory sharing has been adopted by many organizations. According to the P3G catalogues, which are maintained by the international consortium Public Population Project in Genomics (P3G), 66 of the 164 collections of human tissue included in the database grant some sort of access to external researchers. These collections include large population biobanks (with tissue collected from more than 100,000 participants) in Malaysia, Denmark, Australia, the Netherlands, the United States, Saudi Arabia, Taiwan, France, Norway, China, and the United Kingdom.[2] The database also includes an Access Catalogue (www.p3gobservatory.org/access/list.htm)

[2] The results were retrieved by submitting a query to www.p3gobservatory.org/ and selecting "Allow access to biological samples to external researchers."

https://doi.org/10.1017/9781316544587.006 Published online by Cambridge University Press

with detailed information on data and samples for 42 biobanks. The information concerns (1) whether data or samples can be accessed by researchers outside the study/biobank; (2) whether data/samples can leave the study/biobank facility/country under the policies and regulations of the proposed study; (3) restriction to the category/type of investigator requesting access to the study; and (4) limitations regarding the scientific scope of the projects that can use the study's data/sample. An analysis of this data shows that researchers outside the study/biobank can access data and/or samples of all 42 studies. Thirty-six biobanks allow for samples to be transported to a different research facility (domestic and foreign) for analysis. Twenty-seven biobanks allow all kinds of scientific uses of samples and data. Of the 15 biobanks that restrict use, the most commons restrictions involve limiting research to certain diseases or for the uses that are expressly listed in the informed consent. In four cases, the restriction consists merely in approval by an ethics committee.

One of the organizations that has adopted nondiscriminatory sharing is UK Biobank. Researchers from all over the world can access data and tissue stored by UK Biobank on a nondiscriminatory basis. The Access Procedures make the resource accessible to users who are registered and agree to respect certain terms and conditions as long as their research proposals are properly submitted and approved by the biobank. Access is granted "without preferential or exclusive access for any person" and all proposals are subject "to the same application process and approval criteria" (UK Biobank 2011). Moreover, access is granted for a wide range of research projects. Sample and data were in fact collected upon sample sources consenting to any kind of research as long as it is "intended to improve the prevention, diagnosis and treatment of illness, and the promotion of health throughout society" (UK Biobank 2006).

Upon submitting a research proposal detailing what the researcher intends to access (data, sample, tissues and/or recontacting participants) and the scientific rational supporting the study, the biobank managers – the principal investigator and UK Biobank Coordinating Centre – review the proposal. Since the proposals are purposely heterogeneous, the level of scrutiny and requirements vary depending on the nature of the proposal. If researchers request access to data only, the scrutiny is minimal. The level of review is higher for research proposals aiming at accessing stored tissues or involving the recontact of participants, and that are potentially controversial: "Following initial assessment by the executive team, all applications are assessed and either approved or rejected (with right of appeal) by an independent Access Subcommittee" (Sudlow et al. 2015). Occasionally proposals are referred to the University of Oxford's Ethox Centre and the biobanks' Ethics and Governance Council for review in the event the proposed research raises ethical issues.

Data on researchers' access to UK Biobank confirm that the resource has been managed as a commons. Since 2012, more than 1,000 researchers successfully registered to access the resource (Sudlow et al. 2015), and many have been able to ultimately access the biobank with the intent to pursue a wide range of research uses.

According to a summary posted on the UK Biobank's website, research conducted since 2012 has involved 39 topics, ranging from genetics and genotyping studies (not surprisingly the most popular category with 253 proposals), cancer, and cardiovascular disease, to pain, asthma, mental health, and sleep (UK Biobank 2015).

What is also typical of (and perhaps unique to) research infrastructures is that the resource grows through use. In fact, accessing users agree to feed back to UK Biobank the results of their research. Section C11.4 of the Access Procedures provides that "within 6 months of publication or 12 months of when the research project was to be completed, the Applicant PI is required to provide the results of the research, and the raw data behind them, for inclusion in the Resource in such detail and format as UK Biobank reasonably requires" (UK Biobank 2011). Accessing researchers are also under the obligation "to use their best endeavours to publish the findings of any research deriving from the Resource in an academic journal or on an open source publication site within 6 months after the date when it was agreed that the research would be completed" (UK Biobank 2011).

5.4 THE ROLE OF EXPERTS IN SOLVING REGULATORY OBSTACLES AND NEGATIVE EXTERNALITIES

As this survey of policies on access shows, biobanks are increasingly managed as commons, permitting external researchers to access the collection, to extract data and samples from the platform, and to perform scientifically and ethically sound research without predetermined aims. This has not always been the case. In fact, when biobanks emerged as new platforms, the existing regulatory framework – composed of both legal rules and rules-in-use – and a widely popular narrative that genetics was exceptional, and therefore needed special handling, were preconditions for contesting and opposing a commons approach to biobank management. As Frischmann et al. (2014b) point out, the "narratives of creation and operation and [the] history" matter in shaping the attributes of a knowledge commons. This is certainly the case with the emergence of population biobanks. In this section, I explore the evolutionary shift of biobank governance from a non-commons approach to a commons one in some detail. I discuss the regulatory and discursive obstacles to the emergence of biobanks as knowledge commons and argue that biobanking governance experts played a crucial role in reorienting the debate toward a commons approach.

When population biobanks emerged in the 1990s as new research resources, the governance framework that was applied to them by default was composed of traditional principles of scientific research governance. The existing legal rules (international and domestic instruments) (Council for International Organizations of Medical Sciences 2002; World Medical Association 2013) and rules-in-fact (professional guidelines and informal norms) emphasized protections of research subjects through a stringent conception of the requirement of informed consent, recognized the right of researchers

and institutions to control collections, and discouraged resource sharing with external researchers and institutions. This regulatory framework was consequential as it made it difficult for advocates of nondiscriminatory sharing to defend a commons approach to biobank governance.

Two rules were particularly problematic. First, the requirement of informed consent to research was understood as demanding that samples and data could be used only if research subjects disclosed all foreseeable uses in some detail and consented to all of them. This reading of informed consent was a clear obstacle to the emergence of biobanks as research infrastructures for science that was not hypothesis driven. It was an obstacle to establishing both retrospective and prospective biobanks. Retrospective biobanks entailed converting existing collections of samples and data that hospitals, pathology departments, and university labs had maintained for decades before the advent of DNA sequencing. The informed consent taken at that time did not contemplate genetic studies. Many commentators criticized the plan to set up biobanks arguing that a conventional readings of key research ethics governance instruments (Council for International Organizations of Medical Sciences 2002; World Medical Association 2013) prohibited the use of stored samples when intended uses were not foreseen at the time participants had given consent unless every participant was recontacted and agreed to the new uses (Ayme 2003). Unfortunately, recontacting is not a viable option because many of the participants have likely died or moved or, if found, could decline to consent to the new uses. In addition, some argued that the requirement of informed consent inherently prohibits establishing prospective biobanks because research platforms are based on the premise that uses cannot be predicted at the time research participants consent to the storage of samples and data. Informed consent, some argued, was valid only for expressly identified uses (Ghosh 2003). The second obstacle came from the prevailing norm among scientists and clinicians that collections are deemed to be the "property" of the researcher or institution that had established them. This implied the right to exclude other researchers from using the resource, a right that is clearly at odds with nondiscriminatory sharing (Reilly 1999).

In addition to regulatory obstacles, a popular narrative (genetics exceptionalism) fed the discourse that genetic resources presented unique risks and opening access to them would have been unwise and unreasonably dangerous to research subjects and their relatives (Murray 1997; Reilly 1999). According to this narrative, which gained traction in the 1990s, genetic data is qualitatively different from other health-related information in at least three aspects:

> Firstly, genetic tests can provide more accurate data on the likelihood of an individual developing a particular medical condition. Secondly, genetics tests can provide information about the family members of the individuals who is tested, and conversely, the health status of family members can provide information about the

> genetic and future health of the individual. Thirdly, genetic (test) information is more profoundly personal than non-genetic medical information, and one's essential identity is largely determined by one's genetic makeup. (Launis 2003: 90)

Genetic exceptionalism scholars viewed genetic data as "future diaries" (Murray 1997) and maintained that third parties who were given access to this data would read our future lives. This raised concerns that access could result in discrimination against research subjects (Council for Responsible Genetics 1990). Genetic exceptionalism thus represented a powerful narrative against the idea of nondiscriminatory sharing of genetic data stored in biobanks.

In the face of these regulatory and ideological challenges, the community of scholars and policymakers working on biobank governance played a key role in shifting the debate from models that were anchored on protecting research subjects and researcher's ownership of collection to a commons approach. The conceptual shift became possible when members of this community began developing expertise specifically tailored to biobanks. Before the emergence of biobank-tailored expertise, scholars and practitioners had deployed ideas generated in their specific fields (research ethics, health and intellectual property (IP) laws, science management, or basic research) and tended to the existing governance models that I discussed earlier. Many were maintaining an almost dogmatic approach to research subjects' autonomy, which was often deployed as a conceptual tool to restrict the wide range of uses that biobanks were enabling. This was compounded by the then widely shared norm that human tissue collections were "owned" by a certain researcher or lab and not open for sharing with the scientific community. This intellectual posture slowly faded in the background as biobank-specific expertise began emerging in the mid-2000s. Scholars started thinking about and publishing on biobanks' unique characteristics and issues. They participated in policy discussions at the institutional, local, and international levels (Capron et al. 2009). Funding agencies allocated money to study the ethical, legal, and social implications of genomics (also known as ELSI programs), and doctoral and postdoctoral programs began training younger scholars in biobanking governance.

It is thus important to acknowledge the role of experts in breaking path dependency set by existing regulations and professional expertise in reshaping narratives and patterns of interaction around this emerging knowledge commons. Initially both sets of rules generated resistance to the demands for innovation embodied in emerging biobanks. It is through the interventions of resource-specific experts, working in partnership with the scientific community, that the tension between innovation and preservation was mediated and resolved by creating innovative governance paths. These paths have not only enabled innovation but also reformed those rules-in-use in the scientific community and built renewed interest in cooperation among scientists. It was the active role of community members, especially scientists and funders, who pushed biobanking through its initial stages and shaped

its identity as a common pool resource and as a source of knowledge to be widely shared. Policy development was very much driven from the bottom up by practice, where "practice" should be read both as the practice of science (and scientific research) and the practice of governing the resource. Actors with different viewpoints were able to contribute to the discussion as a community and define and redefine governance objectives as the practices evolved as a direct result of technological and scientific change and reflectively as a result of changes in the governance mechanisms.

Since the emergence of resource-specific expertise, the governance debate became enriched with new ideas and approaches. Guided by "practical wisdom" (Knoppers 2004), experts developed a consensus that existing collections and databases could be merged into biobanks (Helgesson et al. 2007) and that participants' consent could be broad enough to encompass future, unknown uses of samples and data (Petrini 2010). A 2012 review of major biobanks' practices shows that 8 out of 11 adopted a broad consent approach and that the other 3 rejected specific consent (Master et al. 2014). In 2013, Steinsbekk et al. (2013: 897) noted that broad consent had been adopted "by many current biobank projects, like UK Biobank, CARTaGENE ... and the Norwegian HUNT study." Furthermore, consensus emerged that biobanks were more valuable resources if a multitude of researchers could access them to pursue a variety of studies (Kaye 2011). Finally, in the United States, proposed changes to the regulatory process for research with human samples would permit biobanks to collect samples using a "brief standard consent form" in which prospective donors agree "to generally permit future research" (Office for Human Research Protections 2011).

Biobanking governance experts thus shifted the narrative from the risks of research subjects to the social value of these nascent infrastructures, opening new opportunities for biobanking. The emerging consensus was that biobanks needed to be purposely designed as versatile resources for open-ended inquiries rather than hypothesis-driven science (Bush and Moore 2012). Regulatory models were refined and focused on issues of data and sample ownership and access, on acceptable levels of risk of traceability of the sample sources, on patentability and benefit-sharing arrangements (Cambon-Thomsen et al. 2007; Capron et al. 2009; Elger et al. 2008; Greely 2007).[3] As a result, *de novo*, large-scale population biobanks were established:[4] they were funded by public money, storing samples collected from scratch and linked to personal information (including medical records, family histories, and other personal data) in ways that protected the identity of the sample source, and meant to be the research community for a wide variety of uses.

[3] The concept of benefit sharing is rooted in the 1992 Rio Convention on Biological Diversity. Although purposely made not applicable to human genetic resources, biobanking scholars used to frame discussions of social value and social justice (Andrews 2005).

[4] These were proposed primarily as tool to study genomics at the population level in Iceland, the United Kingdom, Estonia, Latvia, Sweden, Singapore, and Quebec, Canada (Austin et al. 2003).

5.5 THE SUCCESS OF BIOBANKS AS KNOWLEDGE COMMONS

In March 2009, *Time Magazine* picked biobanking as one of the top 10 ideas changing the world (Park 2009). In 2014, at least 330 biobanks were located in 29 European countries (Kuhn et al. 2015). These and other biobanks are increasingly managed as commons. They are managed as research infrastructures for the study of a broad range of scientific questions that are not precisely determined at the moment the resources are set up and participants consent to the storage of samples and data (Austin et al. 2003: Hansson et al. 2006). They enable basic research that is not always hypothesis driven but rather is often an open-ended inquiry looking for associations between genetic traits and major diseases. Researchers from all over the world can request access. Ordinarily they must submit a proposal to the biobank, which reviews it to make sure it is scientifically and ethically sound and fulfills a public interest in the form of generating knowledge. Users are required to feed data back to the bank so that the resource is enriched by use.

The interactions between users and resources over the past 20 years have led to an impressive degree of maturity in governance approaches. Consistent with other examples within the commons literature, biobanking governance provides a clear example of nested governance (Ostrom 1990). Nested institutions imply an institutional continuum from local to global. Biobanks are governed by multilevel, interacting, nested layers of institutions – from the governing bodies of the resource itself to international law. Governance instruments include informed consent forms, tissue access protocols, material transfer agreements, technology transfer agreements, research agreements among institutions, rules set by consortia, professional organization guidelines, and national and international statutes.

The case study of population biobanks further confirms that bottom-up approaches are effective in governing shared resources. Akin to physical resources, knowledge commons can be organized effectively in nested structures with multiple layers of activities with a regulatory priority of community-based institutions. These layers are organized around the primacy of the local level and an emphasis on rules that are being developed to bind members of a community of practice around a biobank or a consortium. Formal law and the government are increasingly assuming a position of subsidiarity, providing regulatory support for interactions of members of the biobanking community rather than regulating the interactions directly.

While experts should receive credit for the success of population biobanks, endogenous forces have also contribute to the rise of this resource. Technological and scientific developments have reshaped the action arena, to use commons scholars' language (Frischmann et al. 2014a: 35), in ways that favored the use of biobanks by multiple researchers in cooperation. Technological developments include progress in data encryption and database security which have significantly reduced privacy and confidentiality concerns and have increased opportunity for

research exchanges among scientists. The advent of big data and cloud computing facilitated the scaling up of biobanks and also made international collaborations a feasible, efficient, and appealing mode of operation of genomics science. Scientific advancements injected complexity into our understanding of genomics information and their role in explaining health and disease. Most diseases escaped simplistic explanations but required sophisticated conceptual tools to unravel the complexities of the gene/environment interactions as explanatory bases of disease. This change in perspective "normalized" genomics knowledge and took away some of the concerns that had been captured by the concept of genetic exceptionalism. With a less "exceptional" view of genes and more complex and nuanced conceptual models to capture genetic contribution to human health, genomics is now a more layered field in which biobanks play a strategic role as infrastructures that mediate among a vast array of data, forms of knowledge, and expertise. Population biobanks are now strategic infrastructures, established scientifically, and increasingly used by research networks to perform genomics research.

The success of biobanks stems also from their ability to coproduce innovation in science. Biobanks have in fact benefited from macrolevel trends in science and medicine and, in turn, have acted as infrastructures enabling innovation. They contributed to the reduction in cost and time needed generate genomics knowledge, to the rise of data intensive science (Critchlow et al. 2013; Schofield et al. 2010), to the growth of research collaborations among scientists of different countries, and to generating knowledge that is at the root of the paradigm shift toward more personalized forms of health care. As a result, biobanks are now ideally positioned as strategic research infrastructures that facilitate knowledge commons building.

5.6 THE NEXT CHALLENGES IN BIOBANKING GOVERNANCE

Since these resources have been in operation, biobanking governance experts have kept debating and refining their understanding on how to maximize their social value. New governance challenges have also emerged from practice as more researchers are accessing data. For instance, using biobanks in international collaborations (Harris et al. 2012; Kaye 2011) is problematic because of the lack of data-sharing standardization (Knoppers et al. 2011), poor coordination among investigators (Fransson et al. 2015), and legal restriction to the circulation of samples and data (Schulte in den Bäumen, Paci, and Ibarreta 2010). Much governance work has thus focused on (1) improving data and protocol standardization (Hudson et al. 2010; Joly et al. 2012), (2) expanding access for external researchers (Knoppers 2013), (3) harmonizing data privacy regulation (Dove 2015), and (4) identifying the proper way to handle incidental and nonincidental findings that have clinical relevance (Bledsoe et al. 2013; Wolf 2013a, 2013b, Wolf et al. 2012). Biobanks should develop systems for monitoring those who are accessing data as well as explicit sanctions and dispute resolution strategies (Joly et al.

2011). The role of commercial interests in relation to publicly funded biobanks is also being debated (Caulfield et al. 2014; Nilstun et al. 2006; Turner et al. 2013). Rules are being developed in the area of authorship and attribution of work for those who contribute to the management of the infrastructure but are not knowledge generators (in the form of generating research ideas or drafting manuscripts for publication) (Colledge et al. 2013).

While substantial steps have been made in the right direction, the nested institution model for biobank governance lacks key elements. Governance is "thick" at the local level and at the international level but lacking in between. At the local level, governance is robust because of the requirements imposed by research ethics, institutional review of protocols, and the use of contract law to solve issues that include sample and data ownership, data access, funding, and authorship. At the national or international level, laws, declarations, treaties, and judicial opinions also provide a rational (yet contested) governance framework that, with gaps, for the support of biobanks. Moving forward, governance-building work needs to focus on the levels in between. A layer of institutional governance that fosters sharing, collaboration, and sustainability to this important resource needs to be built for biobanks to become effectively embedded in our health systems. The lessons developed by scholars and practitioners of the commons are helpful in identifying the goals and objectives of new governance arrangements, offering suggestions on how the authority vacuum can be filled and contributing to the cultural shift of construing biobanking not only as research infrastructure but also as a public health resource.

Further governance work needs to be done in harmonizing biobanks to guarantee full resource exploitation and minimizing resource pollution and degradation (Karimi-Busheri et al. 2015). Policies were developed at the biobank level or at the level of consortia of research and then spilled over into the field and became norms for more biobanks and consortia. Questions of harmonization, sharing protocols, and quality control became progressively the focus of debates pushing questions of ownership, consent, and confidentiality away from the center of the debate.

Further work also needs to be done toward incorporating patients' views of biobank governance and providing feedback mechanisms to research participants. With regard to patients, a recent study of the cancer patient community in the United Kingdom by Wilcox et al. (2015: 182) concludes that "mutual respect and effective collaboration between lay members and professionals is essential for biobanks to achieve their potential value in health research and thus for future patient benefit." The authors points out that "the consent and willingness of patients and the public to participate in this research will be vital and their involvement will help ensure that the trust and transparency, which is needed, can be maintained (Wilcox et al. 2015: 183). Another recent study, also among patient in the United

Kingdom, shows that participants would welcome a more interactive engagement with the biobank and that they would welcome more information through an online interface (Teare et al. 2015).

A particularly thorny issue is the problem of feeding results back to individuals who decide to participate in a population biobank. It is an issue that has been a contested and complex one to resolve (Wolf et al. 2015).

With regard to the future of population biobanks, my hope is that they will become fully integrated in the public health system and eventually in clinical practice as infrastructures generating knowledge that contributes to assessing health outcomes. With the practice of medicine becoming more "personalized" (Davies 2015), clinicians will increasingly incorporate biobank-generated data into the analysis of a patient's health record. This will close the benefits loop, enhance the collective value of this commons, and reinforce patients' willingness to consent to their tissue and data being stored and used in biobanking. Furthermore, genomics knowledge produced by biobanks will be part, hopefully, of everyday medicine in which patients are treated based on a layered approach to disease (not a full personalized one), driven by an integrated analysis of genotype and phenotype data. Funding will be ensured by the recognition of biobanks as pillars of the public health system. Data will be increasingly shared across borders with members obtaining access based on the promise to respect the terms of agreement of the genomics consortia that make the data available to the community of scientists and clinicians. This way, biobanking will truly spread its wings and achieve its potential as a knowledge commons.

Overall, the case study of biobanking governance reinforces the merits of the framework proposed by Frischmann et al. (2014a: 470) and its usefulness in capturing "the complexity of the interplay among characteristics of particular resources; various communities and groups; and the social, political, economic, and institutional attributes of governance." Biobanking struggled to become a resource with an identity connected to but distinct from traditional biomedical research with human subjects. Its role is, to some extent, still contested and debated as part of the persistent fixation on research subjects' risk and ethics review practices that are not attuned to data-intensive science. A challenge for the future is to overcome one of the weaknesses of the current biobanking governance system, that is, the mid-level governance gap or "authority vacuum," as argued by Jerry Menikoff (2010), the director of the US federal government's Office for Human Research Protections, and developed in the context of biobanks by Dove et al. (2014). Resource governance arrangements must be developed to connect local governance levels with national and international policies. This governance gap is slowing down biobanking growth and eventually could hinder this resource from expressing its full potential as a knowledge commons.

REFERENCES

Andrews, Lori B., Harnessing the Benefits of Biobanks. 33 *Journal of Law, Medicine and Ethics* (1):22–30 (2005).

Austin, M. A., S. Harding, and C. McElroy, Genebanks: A Comparison of Eight Proposed International Genetic Databases. 6 *Public Health Genomics* (1):37–45 (2003).

Ayme, Ségolène, Data Storage and DNA Banking for Biomedical Research: Technical, Social and Ethical Issues. 11 *European Journal Human Genetics* (12):906–8 (2003).

Bledsoe, Marianna J., Ellen Wright Clayton, Amy L. McGuire, William E. Grizzle, P. Pearl O'Rourke, and Nikolajs Zeps, Return of Research Results from Genomic Biobanks: A Call for Data. 15 *Genetics in Medicine* (2):159–60 (2013).

Bush, William S., and Jason H. Moore, 8 Genome-Wide Association Studies. *PLoS Computational Biology* (12):e1002822 (2012).

Cambon-Thomsen, Anne, Emmanuelle Rial-Sebbag, and Bartha M. Knoppers, Trends in Ethical and Legal Frameworks for the Use of Human Biobanks. 30 *European Respiratory Journal* (2):373–82 (2007).

Capron, Alexander Morgan, Alexandre Mauron, Bernice Simone Elger, Andrea Boggio, Agomoni Ganguli-Mitra, and Nikola Biller-Andorno, Ethical Norms and the International Governance of Genetic Databases and Biobanks: Findings from an International Study. 19 *Kennedy Institute of Ethics Journal* (2):101–24 (2009).

Caulfield, Timothy, Sarah Burningham, Yann Joly, Zubin Master, Mahsa Shabani, Pascal Borry, Allan Becker, Michael Burgess, Kathryn Calder, Christine Critchley, Kelly Edwards, Stephanie M. Fullerton, Herbert Gottweis, Robyn Hyde-Lay, Judy Illes, Rosario Isasi, Kazuto Kato, Jane Kaye, Bartha M. Knoppers, John Lynch, Amy McGuire, Eric Meslin, Dianne Nicol, Kieran O'Doherty, Ubaka Ogbogu, Margaret Otlowski, Daryl Pullman, Nola Ries, Chris Scott, Malcolm Sears, Helen Wallace, and Ma'n H. Zawati, A Review of the Key Issues Associated with the Commercialization of Biobanks. 1 *Journal of Law and the Biosciences* (1):94–110 (2014). doi: 10.1093/jlb/lst004.

Colledge, Flora M. A., Bernice S. Elger, and David M. Shaw, "Conferring Authorship": Biobank Stakeholders' Experiences with Publication Credit in Collaborative Research. 8 *PloS ONE* (9):e76686 (2013).

Council for International Organizations of Medical Sciences, International Ethical Guidelines for Biomedical Research Involving Human Subjects (2002). www.cioms.ch/publications/layout_guide2002.pdf

Council for Responsible Genetics, Position Paper on Genetic Discrimination. Position Paper on Human Genome Initiative. 3 *Issues in Reproductive and Genetic Engineering: Journal of International Feminist Analysis* (3):287 (1990).

Critchlow, Terence and Kerstin Kleese Van Dam, *Data-Intensive Science*, Chapman & Hall/CRC Computational Science Series (Boca Raton, FL: CRC 2013).

Davies, Kevin, *The $1,000 Genome: The Revolution in DNA Sequencing and the New Era of Personalized Medicine* (New York: Simon and Schuster 2015).

Dove, Edward S., Biobanks, Data Sharing, and the Drive for a Global Privacy Governance Framework. 43 *Journal of Law, Medicine & Ethics* (4):675–89 (2015). doi: 10.1111/jlme.12311.

Dove, Edward S., Yann Joly, Bartha M. Knoppers, V. Ozdemir, Y. Joly, E. Kirby, and D. Avard, Power to the People: A Wiki-Governance Model for Biobanks. 1 *Genome Biology* 158 (2012).

Dove, Edward S., Bartha M. Knoppers, and Ma'n H. Zawati, Toward an Ethics Safe Harbor for Global Biomedical Research. 1 *Journal of Law and the Biosciences* (1):3–51 (2014). doi: 10.1093/jlb/lst002.

Elger, Bernice S., Nikola Biller-Andorno, Alex Mauron, and Alexander Capron, *Ethical Issues in Governing Biobanks: Global Perspectives* (London: Ashgate 2008).

Fransson, Martin N., Emmanuelle Rial-Sebbag, Mathias Brochhausen, and Jan-Eric Litton, Toward a Common Language for Biobanking. 23 *European Journal Human Genetics* (1):22–28 (2015). doi: 10.1038/ejhg.2014.45.

Frischmann, Brett M., *Infrastructure: The Social Value of Shared Resources* (New York: Oxford University Press 2012).

Frischmann, Brett M., Two Enduring Lessons from Elinor Ostrom. 9 *Journal of Institutional Economics* (4):387–406 (2013).

Frischmann, Brett M., and Mark A. Lemley, Spillovers. 107 *Columbia Law Review* (1):257–301 (2007).

Frischmann, Brett M., Michael J. Madison, and Katherine J. Strandburg (eds.), *Governing Knowledge Commons* (New York: Oxford University Press 2014a).

Frischmann, Brett M., Michael J. Madison, and Katherine J. Strandburg, Governing Knowledge Commons. In *Governing Knowledge Commons* (Brett M. Frischmann, Michael J. Madison, and Katherine J. Strandburg, eds., 1–43. Oxford University Press 2014b).

Ghosh, Pallab, Will Biobank Pay Off? Last modified September 24, 2003. http://news.bbc.co.uk/2/hi/health/3134622.stm

Greely, Henry T., The Uneasy Ethical and Legal Underpinnings of Large-Scale Genomic Biobanks. 8 *Annual Review of Genomics and Human Genetics* 343–64 (2007).

Hansson, Mats G., Joakim Dillner, Claus R. Bartram, Joyce A. Carlson, and Gert Helgesson, Should Donors Be Allowed to Give Broad Consent to Future Biobank Research? 7 *The Lancet Oncology* (3):266–69 (2006).

Harris, Jennifer R., Paul Burton, Bartha M. Knoppers, Klaus Lindpaintner, Marianna Bledsoe, Anthony J. Brookes, Isabelle Budin-Ljosne, Rex Chisholm, David Cox, Mylene Deschenes, Isabel Fortier, Pierre Hainaut, Robert Hewitt, Jane Kaye, Jan-Eric Litton, Andres Metspalu, Bill Ollier, Lyle J. Palmer, Aarno Palotie, Markus Pasterk, Markus Perola, Peter H. J. Riegman, Gert-Jan van Ommen, Martin Yuille, and Kurt Zatloukal, Toward a Roadmap in Global Biobanking for Health. 20 *European Journal Human Genetics* (11):1105–11 (2012).

Helgesson, Gert, Joakim Dillner, Joyce Carlson, Claus R. Bartram, and Mats G. Hansson, Ethical Framework for Previously Collected Biobank Samples. 25 *Nature Biotechnology* (9):973–76 (2007).

Hess, Charlotte, The Unfolding of the Knowledge Commons. 8 *St Antony's International Review* (1):13–24 (2012).

Hess, Charlotte, and Elinor Ostrom, Ideas, Artifacts, and Facilities: Information as a Common-Pool Resource. 66 *Law and Contemporary Problems* (1/2):111–45 (2003).

Hess, Charlotte, and Elinor Ostrom, *Understanding Knowledge as a Commons: From Theory to Practice* (Cambridge, MA: MIT Press 2007).

Hudson, Thomas J., Warwick Anderson, Axel Aretz, Anna D. Barker, Cindy Bell, Rosa R. Bernabé, M. K. Bhan, Fabien Calvo, Iiro Eerola, and Daniela S. Gerhard, International Network of Cancer Genome Projects. 464 *Nature* (7291):993–98 (2010).

Joly, Yann, Edward S. Dove, Bartha M. Knoppers, Martin Bobrow, and Don Chalmers, Data Sharing in the Post-Genomic World: The Experience of the International Cancer Genome Consortium (ICGC) Data Access Compliance Office (DACO). 8 *PLoS Computational Biology* (7):e1002549 (2012).

Joly, Yann, Nik Zeps, and Bartha M. Knoppers, Genomic Databases Access Agreements: Legal Validity and Possible Sanctions. 130 *Human Genetics* (3):441–49 (2011).

Karimi-Busheri, Feridoun and Aghdass Rasouli-Nia, Integration, Networking, and Global Biobanking in the Age of New Biology. In *Biobanking in the 21st Century* (Feridoun Karimi-Busheri, 1–9, Cham: Springer International Publishing 2015).

Kaye, Jane, From Single Biobanks to International Networks: Developing e-Governance. 130 *Human Genetics* (3):377–82 (2011).

Knoppers, Bartha M., Ethics Watch. 5 *Nature Reviews Genetics* (7):485 (2004).

Knoppers, Bartha M., Genomics: From Persons to Populations and Back Again. 56 *Genome* (10):537–39 (2013). doi: 10.1139/gen-2013–0148.

Knoppers, Bartha M., Jennifer R. Harris, Anne Marie Tassé, Isabelle Budin-Ljøsne, Jane Kaye, Mylène Deschênes, and Ma'n H Zawati, Toward a Data Sharing Code of Conduct for International Genomic Research. 3 *Genome Medicine* (7):46 (2011).

Kuhn, Klaus, Raffael Bild, and Helmut Spengler, BBMRI Catalogue. 5 *Journal of Clinical Bioinformatics* (Suppl 1):S19 (2015).

Launis, Veikko, Solidarity, Genetic Discrimination, and Insurance: A Defense of Weak Genetic Exceptionalism. 29 *Social Theory and Practice* (1):87–111 (2003).

Master, Zubin, Lisa Campo-Engelstein, and Timothy Caulfield, Scientists' Perspectives on Consent in the Context of Biobanking Research. 23 *European Journal of Human Genetics* (5):569–74 (2015). doi: 10.1038/ejhg.2014.143.

Menikoff, Jerry, The Paradoxical Problem with Multiple-IRB Review. 363 *New England Journal of Medicine* (17):1591–93 (2010). doi: 10.1056/NEJMp1005101.

Murray, Thomas H., Genetic Exceptionalism and "Future Diaries": Is Genetic Information Different from Other Medical Information. In *Genetic Secrets: Protecting Privacy and Confidentiality in the Genetic Era* (Mark A. Rothstein, ed., 60–73, Yale University Press 1997).

Nilstun, Tore and Göran Hermerén, Human Tissue Samples and Ethics – Attitudes of the General Public in Sweden to Biobank Research. 9 *Medicine, Health Care and Philosophy* (1):81–86 (2006). doi: 10.1007/s11019-005–7984-4.

Office for Human Research Protections, ANPRM for Revision to Common Rule. Accessed June 6, 2011. www.hhs.gov/ohrp/humansubjects/anprm2011page.html.

Organisation for Economic Co-operation and Development, *Creation and Governance of Human Genetic Research Databases* (Paris: OECD 2006).

Ostrom, Elinor, *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge: Cambridge University Press 1990).

Ostrom, Elinor, *The Drama of the Commons* (Washington, DC: National Academy Press 2002).

Park, Alice, 10 Ideas Changing the World Right Now: Biobanks. *Time*, 63 (2009).

Petrini, Carlo, "Broad" Consent, Exceptions to Consent and the Question of Using Biological Samples for Research Purposes Different from the Initial Collection Purpose. 70 *Social Science & Medicine* (2):217–20 (2010). doi: 10.1016/j.socscimed.2009.10.004.

Public Population Project in Genomics and Society (P3G), Biobank Lexicon. www.p3g.org/biobank-lexicon.

Reilly, Philip R., Efforts to Regulate the Collection and Use of Genetic Information. 123 *Archives of Pathology & Laboratory Medicine* (11):1066–70 (1999). doi:10.1043/0003–9985(1999)123<066:ETRTCA>2.0.CO;2.

Schofield, Paul N., Janan Eppig, Eva Huala, Martin Hrabe de Angelis, Mark Harvey, Duncan Davidson, Tom Weaver, Steve Brown, Damian Smedley, Nadia Rosenthal, Klaus Schughart, Vassilis Aidinis, Glauco Tocchini-Valentini, and John M. Hancock, Sustaining the Data and Bioresource Commons. 330 *Science* (6004):592–93 (2010). doi: 10.1126/science.1191506.

Schulte in den Bäumen, Tobias, Daniele Paci, and Dolores Ibarreta, Data Protection and Sample Management in Biobanking – A Legal Dichotomy. 6 *Genomics, Society and Policy* (1):1–14 (2010). doi: 10.1186/1746–5354-6–1-33.

Steinsbekk, Kristin Solum, Bjorn Kare Myskja, and Berge Solberg, Broad Consent versus Dynamic Consent in Biobank Research: Is Passive Participation an Ethical Problem? 21 *European Journal of Human Genetics* (9):897–902 (2013). doi: 10.1038/ejhg.2012.282.

Sudlow, Cathie, John Gallacher, Naomi Allen, Valerie Beral, Paul Burton, John Danesh, Paul Downey, Paul Elliott, Jane Green, Martin Landray, Bette Liu, Paul Matthews, Giok Ong, Jill Pell, Alan Silman, Alan Young, Tim Sprosen, Tim Peakman, and Rory Collins, UK Biobank: An Open Access Resource for Identifying the Causes of a Wide Range of Complex Diseases of Middle and Old Age. 12 *PLoS Med* (3):e1001779 (2015). doi: 10.1371/journal.pmed.1001779.

Teare, Harriet J. A., Michael Morrison, Edgar A. Whitley, and Jane Kaye, Toward "Engagement 2.0": Insights from a Study of Dynamic Consent with Biobank Participants. 1 *Digital Health* 1 (2015). doi: 10.1177/2055207615605644.

Turner, Andrew, Clara Dallaire-Fortier, and Madeleine J. Murtagh, Biobank Economics and the "Commercialization Problem." 7 *Spontaneous Generations: A Journal for the History and Philosophy of Science* (1):69–80 (2013).

UK Biobank, Consent Form (2006). www.ukbiobank.ac.uk/wp-content/uploads/2011/06/Consent_form.pdf

UK Biobank, Access Procedures: Application and Review Procedures for Access to the UK Biobank Resource (2011). www.ukbiobank.ac.uk/wp-content/uploads/2012/09/Access-Procedures-2011.pdf

UK Biobank, Submitted Access Applications by Areas of Interest, Submitted between 30.3.12 and 21.10.15 (2015). www.ukbiobank.ac.uk/wp-content/uploads/2014/12/Approved-areas-of-interest-graph-october-15.png

Wilcox, Maggie, Margaret Grayson, Mairead MacKenzie, Hilary Stobart, Helen Bulbeck, and Robert Flavel, The Importance of Quality Patient Advocacy to Biobanks: A Lay Perspective from Independent Cancer Patients Voice (ICPV), Based in the United Kingdom. In *Biobanking in the 21st Century* (171–83, Springer 2015).

Wolf, Susan M., Return of Individual Research Results and Incidental Findings: Facing the Challenges of Translational Science. 14 *Annual Review of Genomics and Human Genetics* 557–77 (2013a).

Wolf, Susan M., Return of Results in Genomic Biobank Research: Ethics Matters. 15 *Genetics in Medicine* (2):157–59 (2013b).

Wolf, Susan M., Brittney N. Crock, Brian Van Ness, Frances Lawrenz, Jeffrey P. Kahn, Laura M. Beskow, Mildred K. Cho, Michael F. Christman, Robert C. Green, and Ralph Hall, Managing Incidental Findings and Research Results in Genomic Research Involving Biobanks and Archived Data Sets. 14 *Genetics in Medicine* (4):361–84 (2012).

Wolf, Susan M., Rebecca Branum, Barbara A. Koenig, Gloria M. Petersen, Susan A. Berry, Laura M. Beskow, Mary B. Daly, Conrad V. Fernandez, Robert C. Green, and Bonnie S. LeRoy, Returning a Research Participant's Genomic Results to Relatives: Analysis and Recommendations. 43 *Journal of Law, Medicine & Ethics* (3):440–63 (2015).

World Medical Association, World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. 310 *JAMA* (20):2191–94 (2013). doi: 10.1001/jama.2013.281053.