Plants as Digital Things

The Global Circulation of Future Breeding Options and their Storage in Gene Banks

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Abstract: Seeds have traditionally been collected according to their reproductive cycles, i.e. the time when they lose their potential of becoming a real plant. Therefore, the locations of botanic gardens or seed banks imply the vicinity of agricultural land. This article exemplifies the transformation of plant collections into gene and data banks by investigating the Svalbard Global Seed Vault (SGSV) in Norway and the German Genebank for Fruit Crops (DGO). It shows that international efforts to safeguard biodiversity by intertwining them with bioinformatics infrastructure transform seeds and other plant genetic material into digitalized objects. The almost virtual genetic material, now stored without the neighborhood of acres or gardens, is, at the same time, seen as "options" for new high-tech plants, which might be transplanted to a future territory. Consequently, plant varieties are circulating around the globe in form of genetic material and data. The article shows that the digitalization induces a specific distinction between the material and the digital flows of plants.

Keywords: gene bank; digital plant; digitalization; plant collections; svalbard global seed vault.

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1. Plants as Living Organisms and Mobile Biofacts

When discussing mobility, we are used to the idea of large-scale movements, and we tend not to look at the microcosm or little motions surrounding us. Furthermore, we mostly relate mobility to the capacity of changing places. A key characteristic of modern societies seems to be constant global flows of material, people, and commodities. Plants are, of course, part of these flows as they are traded around the world as scientific objects, luxury articles, food and fodder. The EU, for example, estimates the import number of 17,8 million tons and the export number of 44,7 million tons of cereals for the marketing year 2014/2015 (European Commission 2016).

At first glance, 'mobile' plants are those goods flowing through global channels. People move them like all commodities. Yet, although plants are not well known to be mobile in the sense of having the capacity of changing places, they do inherit another type of mobility: As living organisms, they are constantly changing their sizes, colors, and shapes, and they are in a constant metabolic process. Aristotle (II.1) described these life processes as types of motions. According to him, things, which exist by nature, have a principle of motion and of stationary-ness within themselves. The plant's principle of moving is related to growing, withering, and constant alteration.

The principle of movement serves Aristotle as a *dynamic criterion*, which he accompanies with a *genetic criterion* to distinguish natural from artificial entities. For Aristotle, natural entities are those that generated themselves and artificial entities are those that are produced. In production, a projected form is realized by putting together input material following a certain mechanism. That process of synthesizing parts together can, in general, be undone; a ready-made automobile may be taken apart again. Plants, in contrast, reproduce themselves by transmitting a parental form into a newly emerging living being. Here, the 'outcome' is a grown one and cannot be disassembled into its singular components. However, the crucial difference between a produced object and a plant, even a modern high-tech plant, is that the plant, no matter what, still needs to grow.

In the following, I discuss how the digitalization of modern plant collections challenges our interpretation of the ontological status of plants and changes the channels through which plants are moved as mobile objects. Particularly, I want to highlight the dispersion of material and digital networks of flows due to the impact of bioinformatic infrastructures on practices of plant collecting. I am going to analyze two examples: the Svalbard Global Seed Vault (SGSV), a meta-collection of iced seeds on Norway's archipelago in the Arctic Ocean and the German Genebank for Fruit Crops (Deutsche Genbank Obst [DGO]), which is a decentralized gene bank network. Both collections aim to preserve the genetic variety within certain species for the future, and both collections are highly modern in terms of their bioinformatic infrastructure. They both explicitly operate within an international legal framework based on the political will to safeguard biodiversity. We will see that those frameworks demand and push a standardization of plant collections, including their digital data banks. By exemplary examining the rhetoric and practice of two modern plant collections by a study of literature, I will also reveal the interdependencies of the modes and objects of collecting.

2. Collecting Plants: Objects, Discourses and Politics

Currently, about 1750 plant-gene banks exist worldwide (FAO 2010). Their task is to collect samples, characterize and evaluate plants, document this knowledge, conserve the plant material, and finally make the material and the documentation available to others. Gene banks must use different conservation techniques depending on the plant's regenerating systems, e.g. storages at a very low temperature, in-vitro cultures, or field-gene banks. Over the last decades, plant collections have been undergoing tremendous changes (Engels and Visser 2003). Since the 1950s and 1960s plants have become subject to international political efforts, and thus been turned into political and juridical objects. Scientific and technological boosts, in particular molecular biology and bioinformatics, have also turned plants into biotechnological and informationalized objects. These paradigmatic shifts likewise affect the modes and practices of collecting and documenting.

2.1 The Concept of Biofacts

Since the beginning of agriculture in the Neolithic Revolution, plants are being cultivated and farmers, breeders, and scientists initiate and mediate the process of growing by using quite different tools (low-tech or high-tech). Hence, cultivated plants have never precisely grown just by themselves, but were always somehow 'made'. Because of that, the Aristotelian differentiation between the living and the artificial needs specification: We may interpret it as an analytical differentiation between two idealized types (Weber 1997, 90) of how things come into existence. It serves as a scale where objects may be located either closer to the natural or closer to the artificial vanishing points. This scale is very effective on a phenomenological level; for example, one could prefer giving real flowers – in terms of their naturalness – for Fathers day instead of plastic ones, which appear to be more artificial (Birnbacher 2006). However, on an ontological level, the contrast between natural and artificial things seems to be blurred due to the biotechnological control (Thacker 2005), the capitalization (Oliver 2000; Rajan 2006) or the prospecting of life (Hayden 2004; Schiebinger 2004). The dominant character of the ubiquitous technological-economical production paradigm seems to be pushing "naturalness" to a residual or even romantic category.

Against this background Nicole C. Karafyllis (2006) has coined the concept of *biofacts* to refer to those objects, *that grow but not by themselves*. The concept, a conjunction of 'bios' and 'artifact', distinctively relates to the field of living organisms, which are somehow being made. Here, Aristotle's dynamic criterion still serves to distinguish the *bios* from non-living things while his genetic criterion is challenged in the way that biofacts de facto come into existence with the help and under the control of men. As things which are made they are simultaneously artifacts and facts, but as living beings they still differ from usual products. By addressing the Aristotelian scale in terms of growth, the concept of biofacts is useful to explore this ontological hybridity. Growing, in the case of plants, can be examined as a temporal process depending on certain spatial-material conditions. When collected, plants are obviously being de-contextualized – temporally – from the growing-process and – spatially – from their (original) habitats. We may point out different degrees of technization in light of the temporal and spatial de-contextualizations. The crucial point is that biofacts have to be re-contextualized if they are meant to stay living beings. "With globalization, neither concepts nor seeds are fixed in time and space, and every deterritorialization provokes a reterritorialization" (Nazarea and Rhodes 2013, 11). Thus, against the idea of a collapse of the living and the artificial, the concept of biofacts animates us to discuss what we understand as more or less natural and artificial in regard of living things. In order to do so, we need to examine the (political, juridical, economical, scientific, technological) conditions under which biofacts have become what they are.

The concept of bio-facts not only recalls the technological control of life but also stresses the process of constructing scientific facts and artifacts in the domain of life. In this regard it is useful to distinguish semantic and material levels of determining how objects make sense to us. Objects – facts, artifacts, biofacts – are what they are according to those attributes, traits and relations we ascribe to them. Of course, these ascriptions are not completely arbitrary but depend on the natural properties of the objects and the historical contexts in which social practices reproduce and modify their meaning and existence. In the case of plant collections, classifying the collected objects, including identifying them as certain designated entities is especially crucial. As Geoffry Bowker and Susan Leigh Star (2000) have argued, the way things are classified leads to different semantic layers and different layers of infrastructure: political and legal frameworks, scientific knowledge and technological tools and media such as the bioinformatic information infrastructures in the life science.

2.2 The Political and Legal Framework of Collecting Plants

The Food and Agriculture Organization (FAO) of the United Nations has been propagating the threat of "genetic erosion" since the 1960s (Fowler and Mooney 1990; Flitner 1995). The need to safeguard 'biodiversity' was legally manifested through the "Convention on Biodiversity" (CBD), which came into force in 1993, and its following protocols. Territorial rights, intellectual property rights, the concept of ownership, and farmer's rights (Juma 1988; Kevles 2000; Schubert et al. 2011; Carolan 2010) have turned plants into juridical objects what may be understood as part of the broader picture of the politicization of nature (Serres 1995).

In terms of the semantics of biofacts, one of the main achievements of the CBD was to define "biodiversity" in its Article 2:

> Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN 1992, 3).

Each variety level (ecosystems, species, and varieties) corresponds to a preserving strategy, affecting the materiality of the biofacts. Ecosystems may only be conserved *in situ*, which means preserving plants as viable populations in their natural surroundings, or, in the case of cultivated species, "in the surroundings where they have developed their distinctive properties" (UN 1992, 4). Here, plants are preserved in the form of living, embodied organisms subject to a rather low-level of technological control (e.g. protecting the ecosystems from being transformed into building land), thus coming close to the "natural" side of our Aristotelian scale. In so-called *ex-situ* collections plants are conserved outside their "natural habitats," whereby habitat is defined as "the place or type of site where an organism or population naturally occurs" (UN 1992, Article 2). In botanical gardens, which maintain the variety of species, plants are decontextualized from their natural or cultural habitats and re-territorialized into the respective gardens. Here, plants are spatially de-coupled from their origins and their growing process might be subject to a higher degree of technological control in the sense of creating a schedule to prick them out and nurturing their growth. In so-called gene banks intended for preserving the diversity of varieties, we observe even deeper interventions: field gene banks still come close to botanic gardens whereas those plants preserved in vitro (Fig. 1) are in a way spatially decontextualized, which allows a very high degree of technological control about their reproduction-circles (which are downsized and never paused).. Stored seeds (in jars, tins or bags), in contrast, are spatially and temporally detached from their living-conditions. However, gene banks normally have to regenerate all plant material from time to time in order to secure their germability and thus their value. Therefore, all locations of ex situ collections imply the vicinity of agricultural land. Because of that context-dependency, a living plant can never fully become an "immutable mobile" as Latour (1986) described them. Immutable mobiles are easily transportable without changing their inherent characteristics, as, for example, the printed press or emails. As long as collectors want to plant out their collected plants again one day, they cannot completely detach the plant from their growing medias, which would ultimately lead to the plants death. In comparison to archives, the location issue remains crucial for living collections.

Fig. 1 – In Vitro Collection from the Laboratory of microclonal propagation of plants in Uman city (by Красноштан Василь Ігорович).

Another important legal document is the "International Treaty on Plant Genetic Resources" (hereafter the Treaty), which came into force in 2004 (FAO 2009a). The Treaty is officially coherent with the CBD and aims at guaranteeing "food security" (FAO 2009b) through the conservation, exchange and sustainable use of *Plant Genetic Resources for Food and Agriculture* (PGRFA). The Treaty provides a so-called "Standard Material Transfer Agreement" (SMTA), which has to be used by all contracting parties to exchange those PGR, listed in its Annex 1. Furthermore, it recommends establishing a "Global Information System on PGRFA" with standards how to document information and how to build a digital infrastructure. Hereafter, international descriptors, the Global Information Management-System (GRIN GLOBAL), and a web-based catalogue that merges the world's largest databases into one Gateway to Genetic Resources (GENESYS) were built (Nawar 2012).

As the CBD and the Treaty define nearly all related central concepts such as "genetic resource", "genetic material", "ex situ" and "in situ conservation", it is important to see that the CBD and the Treaty do not only serve as legal framework for safeguarding but also as a semantic framework defining what exactly to collect and why (Flitner 1995). This affects the material-side of the biofacts: while traditional seed banks have understood their efforts as collecting cultivars and their wild-relatives (Gäde

1998), such as the Vavilov Institute of Industrial Plants in "St. Petersburg", established in 1926, or the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) in Gatersleben (Germany), established in 1943, gene banks collect genetic material as resources[1]. A *cultivar* is understood as an achievement from a process of cultivation and therefore a past-oriented concept. A *resource*, in contrast, is a future-oriented concept, as something can only be understood as a resource in terms of its usage within a certain process of production. Plant material as a *genetic* resource evokes (at least today) the information paradigm of molecular biology. Information is known to be very flexible in terms of its materialization. Hence, the metaphor of an information carrier presumes plants to be as flexible as information goods in terms of their context-dependency.

Thus, this well-discussed political-legal framework enforces the production-paradigm and shifts our biofacts more to the artificial side on our Aristotelian-scale. Furthermore, it pushes local and regional collectors to standardize their documentation while engaging in international efforts of taking an inventory of the worldwide diversity of crops, as we will see further on.

2.3 The Bioinformatic Impact on Gene Banks

The impact of bioinformatics on plant collections is a research issue on its own. Most of the literature on the conjunction of computer technology and life science in general (Beaulieu 2004; Thacker 2004; Howe et al. 2008) or 'bio-banks' in particular (Fujurama and Fortun 1996; Gottweis and Petersen 2008) have focused on the human and on those gene banks that hold "digitalized genotypic (genetic) and phenotypic (environmental and lifestyle) information" (Ratto and Beaulieu 2007, 176) which have been turned from "well documented, local tissue-sample collections to large-scale bioinformatics resources with a national or supranational scope" (Ratto and Beaulieu 2007, 175) over the last decades. The largest and most prominent collections of that kind are the "Nucleotide Sequence Archive", produced and maintained by the European Bioinformatic Institute, established in 1980 in Heidelberg, the "GenBank" hosted by the US-National Institute of Health, opened in 1982, and the "DNA Data Bank" of Japan released in 1986. These bio-banks are understood to be repositories that store biological samples, mostly human, for research purposes, chiefly in the field of genomics or personalized medicine. Along with the establishment of those large bio-banks STS and History of Science have also gained interest in the practices of collecting and in the role that collections play within the production of scientific knowledge (Bowker 2000a; Strasser 2011). By the impact of molecular

[1] Actually, IPK-researchers seem to use both terms today, "cultivar" and "genetic resources" (Müntz and Wobus 2012).

biology and more powerful and widely used computer technology, the stored data itself, which had been nothing more than a useful annotation in the beginning, has become increasingly important. As DNA-sequencing has become faster and cheaper, data-driven research issues have emerged on the basis of open access data bases and shard hardware capacities, shifting research from *in vivo* to *in silicio* (Marx 2013). By including full clinical records of the donors or information about related research networks today's data and meta-data go far beyond the corresponding samples and reorganize the process of collecting from a sample-oriented approach toward a data-driven approach (Quinlan et al. 2015). Since research becomes less involved with organic tissue, such as blood, milk, and sperm (Swanson 2014), and is more focused on computer-based data mining, it becomes unclear if these inquiries are still investigating biofacts in the sense of men made (parts of) living things or simply artifacts. At any rate, the *bios* as the object of investigation seems to be exclusively modeled through the information paradigm.

It is important to realize that the information paradigm entered the life science in two different ways. First, the shift from population genetics (a formal statistical discipline) to molecular genetics (concerned with the physical-chemical processes and functions of genes) has re-conceptualized genes – in terms of their materiality – as genetic code, using the language of information theory (Kay 2000; Keller 2003; Müller-Wille and Rheinberger 2009). The molecular paradigm interprets growing plants as living expression of genes and *transforms the plant material into information carriers*, readable objects like books. The second entry of the information paradigm are bioinformatic infrastructures, whose impact on molecular research may be summed up as enabling the management and comparison of large amount of data, which could not be handled otherwise, and, speeding up the task of analyzing DNA structures and functions at rather low costs nowadays (Strasser 2011). While the first transformation is primary a scientific one regarding the theoretical options of modeling biological functions, the second transformation is a technological one related to practices that permit producing and sharing scientific knowledge. This shift must actually be understood as a twofold process of digitization and digitalization.

Digitization is understood as the technical process of converting an analogue stream of information or of signals into digital bits, which are of discrete and discontinued value. *Digitalization*, in contrast, is meant to be the way "in which many domains of social life are restructured around digital communication and media infrastructures" (Brennen and Kreis 2014); in particular, the change of scientific practices.

However, plant collections differ from the above mentioned bio-banks in several ways. Their primary duty has not been storing genetic information, but maintaining species or varieties by storing and reproducing plant material and documenting the information necessary for doing so. Still, just like bio-banks, they provide two kinds of resources for both fundamental and applied research: *maintained (plant) material and documented (plant) data*. Yet, bio-banks do not serve the study of biodiversity or pre-breeding processes (Bhatti et al. 2015). Also, empirical investigation must show if there is a comparable shift from 'wet' to 'dry' research in plant collecting (Beaman and Cellinese 2012). I would suppose that the material side of plants plays a larger role here, because unlike the life of the human donors the whole existence of the plants lays in the hands of the collector – especially in the case of endangered species or varieties. Accordingly, plant collections do not only have to maintain bio-samples as possible medical substitutions or sources of knowledge, but also have to manage whole life-forms and control the status of 'being' itself. Therefore, I suppose that plant collections ultimately have to stay sample oriented. Another crucial difference lays in the epistemological status of the samples: in the case of plant collections, the sample refers not to an individual being but to a species or a variety which is being instantiated by the singular sample. We are talking about the digitalization of those abstract entities.

Fig. 2 – Typical herbaria: Geranium (by Sergio Fabris).

Now, the digitization of plant collections concerns the corresponding information, which has been documented systematically for hundreds of years and is now converted into digital data. Using a distinction by Vilém Flusser (2002), the modes in which the information is stored and circulated can be called their *media* and the modes in which the symbolic meaning of the information is organized can be called their *codes*. While media are the channels and materials through which information is exchanged and displayed, the codes are the "symbolic systems" putting the content in order (Bowker 2000a, 647). The digitization of plant collections leads to a media alteration that affects the code in which the information is stored: it becomes more abstract and shifts from more qualitative codes to quantitative ones along the transfer from herbaria (Fig. 2) to books and then to digital sheets. Compared to dried plants, books do not represent the information corporally but symbolically through written language. Through this shift, the information becomes more precise and distinct but also less detailed and rich. The implementation of standardized descriptors used for digital data banks results in an even higher degree of abstraction, again replacing richness with precision. A fruit's color, to give an example, is one of the main traits used to characterize a variety. In books, the color can easily be described in a qualitative way giving credit to graduation and nuances. In his classical directory of apple and pear varities Willi Votteler describes the fruit husk of "Gravensteiner von Saebygard" as "glatt, fettig, grünlichgelb bis gelb, später lebhaft gelb [smooth, greasy, greenish yellow to yellow – later vividly yellow, my translation]" (quoted from Höfer 2015). In contrast to describing a range of color, UPOV (International Union for the Protection of New Varieties of Plants) descriptors for fruit color list fixed tones, such as "yellow" or "green". Even more interestingly, standardized data sheets might not leave space to describe the change of certain traits over time in regard of the plants growing-process. Standardized data sheets detach the plant from its natural existence in terms of freezing its essential time reference into a given set of pull-down-lists that do not leave space for designating constant alterations.

While the digitization of plant collections affects the semantics of the documentations, the process of digitalization builds a bioinformatic infrastructure that creates particular networks and practices. This impact might also be summed up as enabling and speeding up the datification of the documentations and its circulation through new-built networks, as in the case of the above mentioned bio-banks. However, digitalization leads to a specific distinction between the material world and the discursive world (Abbate 1999), consequently generating two different collecting practices, two different collections and two different networks of flows: one of plant material and one of digital plants.

3. Two Modern Gene Banks

Traditional plant collections are national institutions. At present, single seed banks head for trans-nationalization, which import and combine existing collections. They recollect and transform what has been collected before. By doing so, different practices of collecting and different networks of exchanging plants – as material or as data – are invented. Hereby, the material becomes decoupled from the data in terms of their flowing-channels. This happens in quite different ways: while the DGO builds a network of collections only on the digital level the SGSV recollects plant as material *and* as data.

3.1 The Svalbard Global Seed Vault (SGSV)

The SGSV has been built with the help of Norway's government being juridically responsible for the Vault, the Nordic Genetic Research Center (NordGen) providing the scientific basis, and the Global Crop Diversity Trust (Global Trust) paying the running costs. The SGSV consists of nothing more than locked and cooled high shelves accompanied by a systematic digital documentation and managing system. Whereas most traditional gene banks have been research institutions, the SGSV is simply a big storage-room (Fig. 3). When the currently largest plant collection of the world was opened in 2008, it was presented to the public as a "Noah's Ark" and as the "final backup" to protect seeds from natural and human-made catastrophes. The SGSV has been ascribed with religious, eschatological loaded images and metaphors from IT. As a backup copy, the Vault stores duplicates of existing collections. The benefit is not only double safety, but also long-term storage. For example, the gene bank in Aleppo, run by the International Center for Agricultural Research in Dry Areas (ICARDA), had a collection of 135,000 varieties of wheat, fava bean, lentil, chickpea, and barley crops and had sent duplicates to Norway when the war broke out in Syria. Today, ICARDA's scientists, who have left the country as well, plan to regenerate their collections at ICARDA facilities in Morocco and Lebanon, and so they withdrew their duplicates from Svalbard (Conlon 2015).

Let us first take a look at the way Svalbard is recollecting plants. The SGSV explicitly takes the mandate to safeguard biodiversity and presents itself as a global player fighting for food security (Global Trust sd). However, there are different mechanisms at work, selecting which seeds within the general diversity of crops are actually stored there. There is a capacity limit to store 4.5 million varieties of crops (approximately 2.5 billion seeds) at total. Furthermore, the Global Trust covers the shipment costs of those plants listed in the above-mentioned Annex 1 of the Treaty. Finally, the donating banks, which stay owners of the seeds according to the CBD and the Treaty, ultimately decide what they want to send to Svalbard.

Fig. 3 – Inside the Vault (by Dag Endresen).

What happens to the collected seeds by being re-collected (Fig. 4)? First, as Svalbard understands itself as a backup-facility serving other gene banks the re-collected seeds are *duplicates*. Remarkably, the relation between Svalbard and the regular gene banks introduces a differentiation between those seeds stored in Svalbard and those seeds stored at the regular seed banks, which does not correspond to their natural properties but only to Svalbard's mandate to backup other gene banks: the recollected seeds become *copies*, the primary collected seeds become *originals*. Whenever a gene bank needs to reinstall their original collections, as in the case of Syria, Svalbard provides the backup-copy. Here, it is crucial to understand that this differentiation only corresponds to the localization of the seeds and the way they are interchanged. Talking of origins and copies would not make sense otherwise because all collected seeds are equal to one another in terms of being preserved as instantiations of particular species or varieties. Along with becoming a copy, the re-collected seeds in Svalbard also change their purpose. While regular seeds are maintained in order to be planted out one day, Svalbard-seeds are stored in order to re-install collections – that is become original collected seeds again.

Second, the recollected seeds are even more detached from their growing-context because: (a) Svalbard has no soils to plant them out; (b) they are not meant to be planted out but to become original seeds by demand. Accordingly, their reproductive status must be well documented (month and year), and samples should be stored together in accordance to their expected life span, in order to substitute them easily with fresh ones once their time is up. As the process of replacing duplicates to maintain the duplication is not very transparent, this is only speculation: regular gene banks use their own 'originals' to regenerate their collections and to produce new duplicates to send to Svalbard. Thus, the spatial replacement first transforms the re-collected seeds into copies and ultimately into waste – at least in terms of their singular materiality. The Svalbard-seeds might therefore represent the highest degree of technization compared to biofacts stored at regular gene banks. They are spatially further away from corresponding soils and temporally constantly postponed to be planted out – if ever.

Fig. 4 – Storage box for the Nordic Gene Bank's Svalbard Global Seed Bank, (by NordGen/Dag Terje Filip Endresen).

Third, another notable aspect of this initiative is that it does not only hold a meta-collection of what has already been collected by other gene banks, but it also centralizes these collections by merging them all into one single iceberg. That happens *o*n the material level as well as on the data level. Yet, in contrast to the genetic material, which must be decentralized in order to fulfil its purpose (recovering an original collection), this is not true for the recollected data.

In the light of today's international standards, the documentation of plant collections consists of three data sets. FAO and Bioversity International provide standards for *passport data*, which serves to exchange material between gene banks easily (accession's origin, holding institute, storage number). *Characterization data* serves to identify plants and the corresponding international standardized variety-specific descriptors regarding the distinctiveness, uniformity, and stability of a variety are provided by UPOV. These characteristics are traits of high heredity, which means that they are normally passed on from one generation to the next regardless of their growing-contexts (e.g. the colour of a fruit, the growth-form of a tree). *Evaluation data*, in contrast, refers to those traits depending highly on growing conditions. That information does not serve to identify a variety but to assess its agricultural performance (yield). In terms of their economic value as breeding options, seeds therefore intrinsically depend on context-performance.

Accordingly, Svalbard is also semantically re-collecting what has been collected before. In other words, it hosts two different kinds of collections: While the material duplicates are stored in the vault, NordGen (sd) manages the recollected data through a distinct online-catalogue called the "Seed Portal". In line with the Treaty's demands, its data will be merged into the GENESYS-project. The Seed Portal serves two interests: to educate the public about the project and to let the depositors know what is already there and what not. Whenever a gene bank wishes to send duplicates to Svalbard, they are asked to send the corresponding information first. For this, NordGen provides a template on the Seed Portal's website, through which the depositors are asked to hand in an inventory of their donation via email. It hast to comprise the following information (NordGen 2013):

- Institute Code
- Deposit box number
- Collection name
- Accession number
- Full scientific name
- Country of collection or source
- Number of seeds
- Regeneration month and year

Most entries are standardized by international agreements, such as the "institute code" which is part of the FAO's and Bioversity's (2012) "International Multicrop Descriptor" standard. That standard defines the most common descriptors for basic plant characterization and passport data. The full scientific names of plants consist of genus, species, subspecies, authority, and year of description, according to the International Code of Nomenclature for algae, fungi, and plants. The country of origin is supposed to be described in accordance with the ISO-3166 standard defining an alpha-3-code for countries.

This example confirms Bowker and Star's (2000, 34) observation that each classification inherits its history and consists of different layers: "Systems of classification (and of standardization) form a juncture of social organization, moral order, and layers of technical integration. Each subsystem inherits, increasingly as it scales up, the inertia of the installed base of systems that have come before". It also demonstrates that meta-collections enforce international standards: if you want to use the back-up-service you have to adapt your documentation to these standards. There even might be cases, where adjusting the data means a change of media as some gene banks, e.g. in the so-called third world, might not use digital documentations themselves. However, as a consequence, Svalbard holds a rich digital data bank covering – at best – an inventory of the world's gene banks.

3.2 The German Genebank for Fruit Crops (DGO)

As mentioned above, all contracting countries of the Treaty obliged themselves to support a Global Information System regarding the characterization, evaluation, conservation and accessibility of PGRFA. In comparison to the SGSV as a centralized plant storage facility, many other international initiatives are building decentralized networks. One example is the "European Cooperative Program for Plant Genetic Resources" (ECPGR) aiming to build a "safety network for our crops" (ECPGR sd). The ECPGR initiated "The European Genetic Resources Search Catalogue" (EURISCO), a web-based search catalogue providing information about ex situ plant collections maintained in Europe. EURISCO, in contrast to the SGSV's Seed Portal, is based on a European network of ex situ collections and retrieves its data from National Inventories (NIs) from member countries (IPK sd).

The SGSV is run on donations. In practical terms that means that the donating institutes have to ship the material and to submit the data manually. The decentralized networks work quite differently. First of all, the genetic *material* is not being centralized and re-collected but remains within the partner gene-banks of the network. Second, the data flow is technically automatized. And it always flows bottom up.

In Germany, the Federal Ministry for Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft) is responsible for its implementation. As it hosts Germany's NI, it serves as a data interface between EURISCO and Germany's national, regional and local collections (BMELV 2012). The NI gathers data from six different gene banks; the DGO hosted by the Julius-Kühn-Institute (JKI) in Dresden is one of them. The DGO brings together governmental and non-governmental partners as well as private persons. Here, it becomes obvious how much taking an inventory – especially of fruit crops, which cannot be preserved as seeds due to their reproduction biology (Fig. 5) – relies on the engagement of local and regional collectors, run by farmers, breeders, nature conservation associations or individual aficionados. Those smaller collections may apply different standards regarding the storage of material and the characterization and evaluation of the collected objects. Hence, unifying the documentation often includes research on literature to fill documentation gasps or verify given information (particularly regarding a plant's origin). Each partner is obliged to maintain its collection and to provide the data. So, in the beginning, only data is exchanged and centralized – no plant material. While the gene banks stay decentralized, the documentation becomes centralized and monitored by the coordination office at the JKI. Once, the network and its primary digital connections are established, these channels might as well be used to exchange duplicates upon request from breeders, researchers and private persons, which might then also be coordinated centrally.

Fig. 5 – Strawberry Field Gene Bank at the JKI Dresden/Pilnity, (by Bärbel Göring).

The network providing the data for the Global Information System is an interlaced and hierarchical structured system. The higher levels are structured in analogy to political units at international, inter-state (e.g. European), and national levels, while the nationally gathered information depends on local actors. Local partners provide their input. Then, the donated data is collected at the next higher level, in this case, Germany's NI. Then EURISCO imports it. While the data originates from growing contexts and travels 'bottom up' into the World Wide Web crossing different systematical units, the international standards are implemented and concretized top down.

The main goal of the DGO is to take an inventory of all fruit collections with German origin, to rationalize this inventory and to secure its preservation. However, not all fruit varieties are to be preserved. Here, the coordinators ultimately decide which fruit to include and which not (Hanke et al. 2012, 127). The argument of world hunger plays the most important role in most preservation initiatives, but fruit is an exception. It is interesting to see that other reasons become predominant, such as the reason to preserve cultivars with a "socio-cultural, local and historical relation to Germany" (BMEL 2012, 27). Here, the term cultivar is echoed and provided with a second meaning. Cultivars are not only outcomes of agriculture, but they also pass on cultural history. While the "world hunger argument" is mainly future-driven and focuses on basic needs, this argument relies on the past and on tradition. The line of this argumentation, therefore, puts these initiatives somehow close to the cultural work of museums, which strive to maintain history by making material testimonies accessible for a general public. However, the DGO's collection is also based on the argument of changing consumption habits, a future- and profit-oriented reason. While the SGSV serves to back up existing collections, the DGO primarily serves to rationalize Germany's fruit collections and to establish them as a common scientific standard. However, both ultimately serve to take an inventory of the world's PGRFA on the data level. But, what material is actually documented lies in the hands of local actors.

4. Plants as Digital Objects

My article has focused on how the digitalization affects the ontological status of collected plants. By re-collecting what has been collected before, meta-collections produce new types of biofacts and install new networks of flows. Although meta-collections have been technically possible before, it was the digital infrastructure that made them practicable, especially for operating on a supra-national level, if not ultimately on a global scale. In the case of the Svalbard Seed Vault, this process of re-collecting first transforms the re-collected biofacts into copies and the donating collections into originals. Once the re-collected seeds need to be substituted with new duplicates they are, second, most likely to be turned into waste; or – but only in the case of damage – they may be turned into originals again. Only then, the recollected seeds at Svalbard have a real chance to live on. As *copies* and pre-waste biofacts they are shifted closer to the artificial side of the Aristotelian scale. As long as they stay copies, their materiality is only virtually effective as an insurance policy for the originals. Their bios, therefore, becomes secondary in comparison to the seeds in the 'original' collection. Yet, to fulfill their function of being backup-copies they must inherit the capacity to grow and (virtually) stay living things. The German Genebank for Fruit Crops, in contrast, does not directly affect the materiality of the biofacts, which themselves stay with the partners of the 'decentralized' network, although it makes them more visible for potential customers or researchers through its web catalogue.

By re-collecting information, the SGSV and the DGO produce digitized, centralized and standardized data. Semantically, the information becomes more abstract, distinctive and precise but also less rich and vivid. However, what happens on the material-side of the information is more substantial: the digital infrastructure, hand in hand with international political efforts, induces the specific distinction between the world of material and the world of digital plants which travel through different channels and networks. Three questions arise and need further investigation: (1) how does the digitalization alter the relationship between the material and the digital plant? (2) how does it transform the study of plants and biodiversity? (3) do we need a new information policy?

Information about plants has always had an ambiguous status. Epistemologically, it has always been independent of singular material plants in the sense that the knowledge which it offers is not limited to those singular material plants it has inductively been gathered from but refers to varieties or species. As general knowledge, the plant documentation – regardless of its codes and media – has always been an independent object. Conversely, the information, not as knowledge but as documentation, has always been ontologically linked to a specific collection and has not existed, traveled or being stored as an independent object until now: digital plants are being shared and exchanged without the corresponding material transforming the linkage between the documentation and the corresponding material into a virtual one. Furthermore, as in the case of biobanks, distinctive data-driven research issues might emerge on the basis of these newly created global plant data banks using the possibilities of linking large amounts of data, e.g. for mapping biodiversity (Bowker 2000b). Through this process the information is transformed into a global documentation discarding its characteristic of being documentations of specific collections. Maybe, the information stored in the Seed Portal of the SGSV will once be considered a primary source for research, thereby turning the historically original documentations into their 'backup copies'.

Because of the dominance of digital plants, it seems that meta-collections are not primarily collecting bio-facts anymore but data. Remarkably, this specific distinction of material and digital flows in the plant community has not been subject to a lot of debates until now. Whilst there is a legal framework for the flow of plant material and while there have been many arguments about authorship and credit as well as ownership and inventions in case of the data of the bio-banks (Strasser 2011), there has been little debate on the question of the flow of digital plants. Here, the crucial question would be, what kind of values the new data banks create and whom they can and will serve. Nonetheless, bioinformatic infrastructures already build technological momentum (Hughes 1994): once the documentation is digitized this media shift seems irreversible (Bowker and Star 2000). Once large networks keep digital plants flowing it might be hard to control the flow of information or even implement traffic rules.

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