Do-It-Yourself biology (DIYbio): Return of the Folly of Empiricism and Living Instruments

Biohacking [1, 2], Indie biotech [3], Biopunk and Do-It-Yourself biology (DIYbio) [4, 5], but also garage biotechnology [6] present various attempts to use open science paradigms, but also e-science tools for collaboration, sharing of data and protocols, to support citizen science projects, bioenterpreneurship, new design practices, but also policy discussions on biotechnology. While the movement, which appeared around 2008 - 2009, shares many interests with Bioart [7, 8], but also cultural research in biotechnology [9, 10], its primary focus remains bioenterpreneurship, bioprospecting, science communication and public participation in science rather than issues of biotech aesthetics, bioethics, biopolitics etc. The main goal is democratization rather than aesthetic or critical engagements with science, and this is often voiced as an interest in open data and building open hardware infrastructure, which support efforts for open science in the Global South [11, 12]. Paradoxically however, the DIYbio does embody an original artistic concept and design fiction scenario by Natalia Jeremijenko and Heath Bunting in 2005, who published the first ever journal for "describing radical, critical, but also playful biotech activities extrapolating the future, extreme bio-tech adoption [13].

Return of the laboratory as a private and public, rather than a corporate space

While most bioart projects reflect and use biotechnologies in the context of various art institutions and galleries, the DIYbio and biohacking efforts grow and spread through the emergent culture of hackerspaces, makerspaces and citizen science laboratories. Rather than simulating the laboratory in the gallery and public space, or enabling amateurs to visit and take part in the guarded activities of the closed laboratory, the DIYbio movement is trying to transform the laboratory into a public space or even nomadic, temporal, and movable space [14]. In this sense, it reminds us of the origins of the laboratory as a special theatre, in which not only new knowledge, but also new politics is envisioned and negotiated around new actors entering our common world [15, 16]. This is the angle, through which we want to discuss the present DIYbio movement as a return of the private and public functions of the laboratory. We see a value in this revival of the mechanical arts and pre-modern science for their appreciation of tinkering and more holistic and complex involvements with the society and the arts of their period.

This short archaeology of the DIYbio, inspired by the brilliant work of a historian of science, Vera Keller [17], will emphasize the importance of tinkering as a practice, which back in the 16.century as well as today in the hackerspaces, enables original engagements between politics and science over prototypes. The "folly of empiricism", how tinkering is ridiculed in the 16.century, refuses to accept any pre-given ideas or to bend to authorities of any kind. It is an eclectic and holistic approach to experiments, which results in prototypes that are never just useful tools resolving a particular problem or serving pre-defined goals . Prototypes are "living instruments" [18] expressing scientific as much as cosmological insights, but also political and social ideals. Nowadays we are trying to articulate the various visions of open hardware being a tool for democratizing science and better oversight, which can even support research in the developed world. The "living instruments" as an expression of makers knowledge in history, but also today with DIYbio open laboratory equipment, are not mere tools for experiments. They are the experiment, they are an attempt to bring science and politics together through tools, which enable us to formulate new questions and test various visions of the common future. The DIYbio prototypes as "living instruments" bring together and put in relation different ideals, objects, but also institutions and environments. They show how the goal of innovation can go hand in hand with the goal of public participation and oversight of science, how we can create new value chains and relations between individuals, communities and countries, which go against the biotech corporate monopolies guarded by agencies, such as the FBI.

DIYbio between media frenzy, academic reflections and FBI paranoia

The popularity of the DIYbio movement was never purely a matter of the technologies used (synthetic biology, genetic engineering), but more due to the personalities with strong media presence, which superseded and defined this movement. The biotech adventurers and visionaries, such as Craig Venter, George Church or Drew Endy, managed to fuel the public imagination in the early millennium with powerful visions of the biotechnology in the future [19]. The media were simply prepared and expecting the second generation of famous biohackers, such as Meredith Patterson or Mackenzie Cowell, who appeared around 2008- 2009, followed by a surge of emerging organizations and spaces, such as GenSpace NYC [20], MadLab UK [21], Hackteria network [22], Biocurious in Mountain View [23] etc. Between 2008 - 2010 the whole DIYbio movement was still emerging from the iGEM milieu [24], basically recycling and connecting the existing future biotech memes defined on one side by Craig Venter (and Drew Endy) and his visions of bioenterpreurnship [25], and on the other side by George Church and his emphasis on publically funded, open, citizen science [26]. Only after 2010 the movement is rapidly globalizing and diversifying, connecting with the hackerspace and makerspace open science, citizen science projects, and responding to local needs [12].

In the present there are about 3000 members on the DIYbio Google group [27], where about 100 of them are part of some laboratory or really working on concrete projects [28]. In 2009 - 2011 the movement also attracted attention from various government institutions, among others FBI, which at that time emerged and tried to save face in the infamous scandal (2004 - 2008) of arresting, financially ruining and humiliating a known bioartist, Steve Kurtz [29], while pretend it is fighting bioterrorism. Very important for the U.S. based DIYbio activities is the support of the policy think tank, Woodrow Wilson International Center for Scholars, based in Washington, D.C., who over the years organized various workshops (in cooperation with the FBI), but also invited DIYbio representatives to public hearings. In 2013 the Wilson Center summarized its engagements with the DIYbio in an official report on the "Seven Myths & Realities about Do-It-Yourself Biology" [30] based on the first ever survey of DIYbio practitioners. The report claims that the movement in its current phase does not represent any risk, but it is an opportunity for education and entrepreneurship. Another commissioned report by the German Bundestag on the global DIYbio movement is about to be published in 2014 [31] reflecting among other issues also these policy engagements around DIYbio in the U.S., which did not make a positive impression on some of the members of the movement in EU and Asia (among them also the author of this paper), who actually refused to take part in the survey. The German report also notices the importance of the movement for science communication and public engagement in biosciences. In terms of these policy papers, there is also a short summary and a report prepared for the UNESCO on the importance of DIYbio for supporting research in the developing countries [32], and a white paper with policy recommendations on how to support the interdisciplinary STEM goals prepared for SEAD (Network for Science, Engineering, Arts & Design) [33]. The interest in policy also influenced some original reflections and attempts for "codes of conducts" inside the DIYbio [34, 35].

While the media were busy glorifying or misusing the emergent biohackers for their wild scenarios about the future, which was helping the booming security business surrounding antiterrorism rather than entrepreneurship, the academics started to reflect upon the movement around 2012. The DIYbio was discussed in terms of its relation to open science advocacy and issues of corporatization of science in the first academic book on the issue [36]. It was also discussed in several journal articles in terms of the e-science models of sharing knowledge and their support of makers and hackers movements [37], as a model for supporting bioenterpreneurship [38] or even a model for HCI research into hybrid bio-electronic design, which supports interactions between stakeholders, materials and concerns [39]. Recently, we see more attempts to discuss the DIYbio in terms of

public participation in science, reflecting upon the role DIYbio prototypes play in forming the identities of various communities and empowering them to envision their future [11, 12, 40, 41]. The question is not only what type of science, business, design or even policy the DIYbio enables, but also what type of a community we can are creating around similar citizen science, Quantified Self etc. engagements with science.

This last question relates directly to an important issue, which we want to discuss in our modest archaeology of the movement: how independent is science on politics? What is the relation of the laboratory spaces to our community, public and private spaces? Do we have to mediate these relations through various policy actors? The emergent body of literature reflects upon the disruptive DIYbio effects on various systems (business, policy, research) [37, 38, 39] and opens interesting questions, whether the DIYbio is an issues of governance of science or creativity, innovation, economic incentives, democratization etc. In this paper, we would like to concentrate on the hybrid ability of the DIYbio to create unexpected "syntheses", especially between prototypes and communities [11, 39]. We will claim that this is more of a return to premodern science [16] after centuries of embracing the ideal of "division of powers" between knowledge and policy, science and society, where every tool, protocol, design or law belongs to clearly defined space and to the experts. By creating DIYbio prototypes in a community setting we are engaging not only with open science data and hardware, but also negotiating and designing new codes of conducts and policies vis–à–vis various new entities, and to imagine and articulate a very different future and maybe even a world.

The DIYbio is like some return of the repressed "folly of empiricism", where we are engaging with something similar to the Renaissance "living instruments", prototypes, which enable more global and even cosmological reflections, or how Keller describes them as "forgotten fantasy — a single, living machine that could encapsulate, prove, and effortlessly convey universal knowledge of nature" [18]. The Renaissance prototypes designed by mechanical artist and philosophers, such as Cornelius Drebbel [17, 18], were just like the DIYbio prototypes a probe into new ways of imagining not only science, but also society and the universe: "Drebel never intended his object to be merely an instrument of measurement, but rather a moving microcosm or compendium of all natural knowledge to be observed in a glance. Contemporaries usually called this a perpetual motion, and we might term it a cosmoscope... The cosmoscope suggested a single, pansophic artisanal philosopher, who based his knowledge in his own manual construction of a working microcosm that validated all of his theories. This model entailed a close association between the body of the artisan and the content of his own natural philosophy encapsulated within his single, personal device." [18]

DIYbio as a Premodern Science

The DIYbio in this sense shares certain characteristic of the premodern disciplines [16], such as alchemy and mechanical arts, closely connected to natural philosophy, that go against the modern divisions between primary and applied research, professional and lay knowledge, science and philosophy etc. The speculative and tinkering nature of both Renaissance mechanical arts and today's DIYbio, especially their "design" focus on provisional prototypes rather than pre-given (and patented) tools productively integrates these divisions. Even the “engineering ethos” in sciences [42, 43] apparent in synthetic biology as a precursor of DIYbio reminds us of the “mechanical arts” (artes mechanicae) and the debates surrounding the status of the experimental sciences in the so called “Baconism” [44]. By using iterative design processes and tinkering, DIYbio manages to mix various domains of knowledge, industry needs, and public (user) sensibilities without defining in advance our individual and collective goals. Furthermore, innovation is expected not only in terms of actual science but also in terms of its social and ethical aspects, the actual processes of dissemination, public participation and adoption, which are performatively „upstreamed“ and can even influence

the research agenda. Rather than some ideal of scientific truth, economic and business value or clearly defined social or ethical values, DIYbio offers only tentative, processual, and experimental results in all these domains. This decentralized, participatory, and design oriented practices fueled by open science, wiki style communication, knowledge sharing and deliberation, embody this emergent, alternative R&D culture. The relation between the tentative norms, which are open for experiments over the DIYbio Google list, and the science protocols leads to reiterative prototypes, which characterize them as "living instruments" [40] - novel attempts to bring together theory and practice, but also science and communities rather than abstract “society”.

The present divisions between primary and applied research, university and industry, professional and lay knowledge, science and policy, is a historical relic of the „Baconian“ insistence on both autonomy and regulation of science and its method. This insistence served an important function back in the 16.century to protect the science against scholastic and overly regulated, theoretical and theological discussions of nature, but more importantly it was also a protection against the wild and unregulated powers of mechanical arts and its serendipitous “experimenta fructifera” providing results without any theoretical basis and system [45]. Bacon placed his scientific experiments producing knowledge and not only practical effects (experimenta lucifera) against the tinkering experiments of the mechanical arts. He claimed that his well-documented experiments with shareable protocols will bring controllable knowledge and sustainable innovation as means of restoring human power over the creation (instauration) which is the goal of both science and religion [46]. While his inductive and qualitative method is often discussed in the history of science, these ethical, social and religious claims identified with the theological project of “instauration” of the original human condition are rarely mentioned or discussed. We even follow the ethical and social aspirations of this religious project of a return to some pre-defined and ideal state, which was translated into the humanist and enlightenment ideals of rational order in human affairs leading to progress [47]. Indirectly, these sentiments are also expressed in the present pleas of the biotech industry to the state actors to enforce more strict patent regulations and protections in order to help the biotechnology sector, which supposedly will need this to guarantee innovation [48]. What remains forgotten are the alternative projects by other mechanical artists and alchemist in Bacon’s time on how to bring science and society, technological advancements and social progress together, which placed much stronger emphasis on tinkering rather than a system and method, and were simply more plural in terms of their values and open, where the metaphor of the return was one of many [49, 50].

DIYbio as a critique of Bacon's "instauratio"

In this paper we are defining the DIYbio as a return of an old debate on how to bring together knowledge (scientific truth, protocols), social discourse (customs, ideals) and public values (norms, laws). While the mechanical arts were connecting science protocols with various social, political norms and even mythical motives and aesthetic values in an ad hoc fashion, the Baconian project promised a method that will bring progress to both (science and society) if it is regulated by clearly defined actors and divided. It was this idea of a method that will restore human powers over the creation (nature) and then automatically lead to the moral improvement (instauratio, return to the godlike condition) of humanity, which influenced all our modern ideas of science and society interactions.

Bacon’s vision of “instauratio” [46] informs the whole modern project of science as a pursuit for maximum efficiency and performance that will magically resolve all social and human problems. This “modern” implementation of “instauratio” is problematic not because of its insistence on the empirical and experimental sciences and knowledge but because of these particular views of moral virtue being something we can simply restore, something non-experimental but given in advance by

supernatural and transcendental authority. That the right (scientific) knowledge will bring moral and other improvement is based on a theological idea about the power over the creation given to man by God [46]. The moral advancement will automatically follow our knowledge about nature which we will "re-gain" with science and power and restore via technology. The idea of technocratic solutions to every problem is just a simplified version of this original theological position in Bacon, which defines the whole modern project of science and its institutional strict separations of domain of knowledge and practice. It is an idea that teaches us that it is enough to trust the institutions, which advance the scientists to bring benefits to the society, because there is some ontological (and religious) connection between knowledge and morality.

Bacon's "instauratio" simply states that resolving uncertainty in our knowledge of nature will automatically create a moral certainty together with social and political stability. In the Renaissance this is not a unique position but there are also other projects and possibilities, which were probed, on how to connect new science, technological tools and social structures. Alchemists and tinkerers such as Johann Becher [50] or Cornelis Drebbel [17, 18] offered a more plural view of these interactions between society and science, facts and norms , often based on the alchemist ideal of the "inner", personal work and experiments being as important as the experiments in the laboratory, and which were being simply more processual and less certain about is outcomes. Every scientific fact has its social and political, but also personal reality for the alchemist, and they view this reality as something experimental rather than final, always open to contingencies and practices [50].

Maker's knowledge works with "scientific" facts that are embedded in a very rich and plural system of symbolic, ethical, theological and even personal implications and meanings, in iconography with paradoxical and often provocative imagery addressing small groups of "adepts" and individuals rather than the larger society. They connect the scholarly, artisanal, and entrepreneurial forms of knowledge and offer an alternative perspective on what is the ideal science and society interaction: "*As the issue of practice increasingly has come to the fore, alchemy now appears to be a fitting emblem for studies that aim to incorporate a broad array of practitioners and forms of natural knowledge into narratives about the emergence of the "new science" in the early modern period. Simultaneously bookish, experiential, and experimental, alchemy stubbornly resists any attempt to separate out the histories of reading, writing, making, and doing. In fact, it demands that these various engagements with nature, the relationships among them, and the people of all social strata who created them all be kept in play in any account of its history. In this sense, alchemy offers a model for thinking about early modern science more generally, particularly in light of recent work that has explored the intersection of scholarly, artisanal, and entrepreneurial forms of knowledge"* [48].

As these recent studies of alchemy show [48, 49], tinkering and entrepreneurial knowledge was deeply embedded into the artisanal and commercial culture of the Renaissance period and served various visions of society. The present insistence on design and entrepreneurship in synthetic biology, but also DIYbio revive these complex interactions between science, community, business and even arts and entertainment. Their rich interdisciplinary connections often involving the public fantasy (business, design, art, Science Fiction, media) embody this "premodern" aspect and revive the ability of science to bring forth creative and imaginative convergences by using tinkering and opening both science and society to pluralistic views and experiments with the future.

Conclusion

The hybrid and hard to define organisms, materials, disciplines, and institutions around the DIYbio movement raise suspicion for their supposed novelty, risk, and radicalism, but they pertain certain

premodern characteristics, which we claim bring closer and more experimental approach to policy. The interactions between science, politics, and business in the premodern period incited very unique and utopian projects by various mechanical artists, alchemist and tinkerers. The scientific facts and technologies created in the "laboratories" of the 16. and 17.century were supporting variety of economic, political, but also theological and religious projects and ideas. The present convergences revive this plural and anarchistic model of interaction between sciences and society and present an opportunity to understand the genealogy of sciences themselves, but also the limits of the separation between ethical norms (social order) and protocols (scientific discoveries). The present models of connecting ICTs, engineering, and biology with ethical and social experiments in DIYbio, but also synthetic biology, revive these debates surrounding mechanical arts and tinkering in the 16. and 17.century, which played a crucial role in defining the modern aspirations of science. We need to look back into how the tools of discovery and knowledge production were also simultaneously used for community building in the premodern period to asses and regulate activities, such as DIYbio, iGEM, and various forms of public participation in emergent sciences. With DIYbio we are witnessing interactions between institutions, norms, and facts, which integrate theory and practice, truth and value, science and politics in an experimental fashion resembling the premodern situation. These convergences revive the Renaissance experiments between the court and the alternative networks of scientists and researchers, which appeared in Europe. It revives an alternative model of science, technology, and society interaction which we call "premodern" for its reference to tinkering and Renaissance "artes mechanicae". Before the Royal Academy of Arts was established as a standard model for all future science and society interactions, mechanical arts and natural philosophy were experimenting with various forms of connecting emergent science with what was called the "court" (politics, society). The genealogy of these plural interactions between science and society (protocols and norms) can give us a valuable perspective on the present situation as an opportunity rather than a demise of ontological, social, ethical etc. values and aspirations.

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