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GENOME HACKERS
REBEL BIOLOGY, OPEN SOURCE AND SCIENCE ETHIC

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Part I

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Introduction: cracking codes, remixing cultures

> *Yes, I am a criminal. My crime is that of curiosity. My crime is that of judging people by what they say and think, not what they look like. My crime is that of outsmarting you, something that you will never forgive me for.*
> *The Hacker Manifesto, 1986*

Crack the code, share your data, have fun, save the world, be independent, become famous and make a lot of money. In this study I link the public image of contemporary scientists devoted to open biology to the ethics and myths of the hero of the computer revolution and of informational capitalism: the hacker. I suggest the existence of a remix between the Mertonian ethic, the famous account of scientist's norms of behaviour proposed in the 1930s by the science sociologist Robert Merton (1973) and the hacker ethic, a set of moral norms that emerged in the 1960s within the first hacker communities in the United States and was formalised for the first time in 1984 by Stephen Levy in his bible of hackers' history (Levy 2010). I point out an emerging open science culture that mixes rebellion and openness, anti-establishment critique and insistence on informational metaphors and operates in a context of crisis (Boltanski and Thevenot 2006, Bourdieu 2004, Swidler 1986) where the relationship between researchers, scientific institutions and intellectual property is redefined. In this way I tackle two main problems, one of which is the role of open science within the framework of informational and digital capitalism. The opposition between openness and closure is not the only problem to consider if we want to understand today biology's transformations. The other is the evolution of scientists' culture and how it interacts with the way science is done, distributed, shared and commercialized. Indeed, by analysing both discursive strategies and socioeconomic practices of contemporary biologists who use open science tools, I investigate their role in the changing relationship between science and society. The case studies I analyse are not impartial and not generalisable, yet I argue these biologists can be a rich model for current transformations in both life sciences and informational capitalism. In particular, the culture to which I am referring gives scientists rhetorical tools they can use in order to solve some of the political and societal problems raised by the increasing privatisation of genetic research by means of patents and other restrictions to access to biological data. It can also be considered as an expression of a change in the institutional and socioeconomic settings of contemporary biology, in which open and closed models of intellectual property coexist a in a complex configuration. Finally, I point out these biologists' role in hacking biology. Hacking as an active approach at the shaping of the proprietary structure of scientific information - who owns and disposes of biological data and knowledge? But also as a challenge to Big Bio, the ensemble of big corporations, global universities and international and government agencies that compose the economic system of current life sciences. A challenge that aims at modifying the institutional environment in which biological research takes place.

The tragedy

The most common, and naïve narrative about open science tells us that once upon a time, ethics in science was a good thing: sharing, equality, disinterest and the common good drove the everyday work of scientists. Then evil corporations entered science and changed the rules of the game, patenting life, enclosing the commons, and eventually destroying the willingness to share data, information and knowledge. But today, so the story goes, we have new tools that together with the old open science spirit can be used to rebel against evil, defeat it and allow scientific knowledge to flow freely again. These tools are open source and open access science, and they can be used to tear down the barriers to the access of scientific knowledge.

The expression «tragedy of anticommons» comes from a famous paper published by *Science* in 1998 (Heller and Eisenberg). According to this formula, the proliferation of restrictions to access, patents and industrial secrets represents an obstacle to innovation. Michael Heller and Rebecca Eisenberg reverse the classic perspective on the «tragedy of the commons,» 1968 Garrett Hardin's widely cited paper that has been used as an example of the necessity of centralized management, or privatization, of common goods. In a well-known passage, Hardin stated that no pasture can be managed as a commons forever.

> Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. (...) As a rational being, each

> herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he (...) concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all (Hardin 1968, p. 1244)

Hardin's position has been criticized from several perspectives. On one hand, according to the definition by Nobel Laureate Elinor Ostrom (1990), the commons should be interpreted as an «institution for collective action» that only a hasty and individualistic approach can lead to ruin. On the other hand, informational commons famously have distinctive characteristics. Information is said to be a non-rival good: no cattle can get through an informational pasture, for using a piece of information does not prevent anybody else from using it. In fact, intellectual property rights are artificial enclosures needed to extract value from a resource that is indefinitely replicable (Lessig 2002). According to Heller and Eisenberg and their diametrically different perspective on the commons problem, the increase of patenting in biotechnology inhibits innovation, forcing actors to navigate a complex and atomized territory were intellectual property rights owned by several distinct parties raise the cost of doing research.[1] The cause of the anticommons effect is the fragmentation of property rights and the increased number and scope of barriers to access vis-a-vis the necessity of «assembling of an assortment of complementary bits of knowledge and research tools, each of which might be owned by distinct parties» (David 2003, p. 13; for an example of anticommons in genomics see Maurer 2006). Furthermore, according to social studies of science anticommons are also a symptom of the changes in the relationship between science, capital and society. As seen in Helga Nowotny's Mode 2 Science (2001), or John Ziman's Post-Academic Science (2000) the relationship between corporations and science has become stronger, causing a general reconfiguration of the roles and dynamics of scientific research.

[1] Other studies suggest that anticommons caused by gene patenting have never materialized, even though those fears continue to have an important effect on policy making (Caulfield et al. 2006)

Commodification is part of «a major shift in the social relations of knowledge production» (Hedgecoe and Martin 2008, see also Hilgartner 1995). Finally, the rise of anticommons has been interpreted as a cause of corruption of the norms of good science, expressed by the adherence to corporate values and goals by the producers of scientific knowledge.[2] Patenting, secrecy and the quest for profit radically conflict with the norms of modern open science, namely with the «commitment to the ethos of cooperative inquiry and to free sharing of knowledge» (David 2003, p. 3). And free and open dissemination of knowledge remains an important ideal associated with scientific progress. According to many authors and open access advocates, we need to couple the rise of new technological tools with a restoration of the modern open science culture. For Victoria Stodden, today's open science movement is not updating the social contract of science: «what we're doing is returning to the scientific method which has been around for hundreds of years. It is what a scientist is supposed to do» (Stodden 2010b; see also Hope 2008). The Budapest Open Access Initiative (2001), one of the main manifestos of the open access movement in scholarly publication, opens by combining the old open science culture and the new information and communication technologies:

> An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the world-wide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds.

But my point is exactly that «the old tradition» of open science ethos is not enough to understand the transformations we are facing. In order to present a different viewpoint on this story, I use the hacker ethic as an analytical tool to study three open biology research projects. It allows me to highlight the emergence of a new open science culture among biologists, evolving from the 20th century Mertonian ethic but also comprised of several new cultural elements. In

[2] Heller and Eisenberg 1998, see also Nowotny et al. 2001, Hedgecoe and Martin 2008. For an historical perspective on open science see David 2003 and Eamon 1990

his 1942 accounts of scientists' behaviour, *The normative structure of science,* Robert Merton famously proposed what is now a classic list of norms of behaviour which govern academic scientist's work and science's functioning. The norms that guide research practices, later summarized by the acronym CUDOS, are communalism, universalism, disinterestedness and organized skepticism. These imperatives are linked to rewards given to members of the scientific community who follow them, and sanctions applied to those who violate them. *Communalism* means that scientific data are a common good and need to be shared freely. Individual creativity must be recognized in the form of authorship, not ownership. *Universalism* means that science can not use criteria such as race, religion or personal qualities to evaluate scientific claims. *Disinterestedness* is a norm against fraud and against the intrusion of personal interests in scientific activity. *Organized Skepticism* states that the whole scientific community must be able to check facts and ideas until they are well-established and recognized.

Autonomy and disinterestedness are also two of the main characteristics of Michael Polanyi's Republic of Science (1962). Polanyi uses the scientific community as a model for democratic societies. According to him, the free cooperation and self co-ordination of scientists are directed towards the discovery of «a hidden system of things», and the search for originality «encourages dissent». The authority of the Republic «is established between scientists, not above them». But once established, authority does not need to be rejected. Rejection of authority happens during crisis, during oppositional and controversial times in which scientists can decide to overthrow who reigns over the Republic. Yet as historians and sociologists have pointed out, the Mertonian ethic is neither an accurate description of scientists' work nor a set of moral norms scientists should follow. More recent work in the sociology of science has identified a number of problems in Merton's proposal, namely in the importance of disagreement and controversies that are not deviations from a consensual norm but rather ubiquitous characteristics of the scientific enterprise (Collins and Pinch 1994, Laudan 1982). Furthermore, the norms of disinterestedness and objectivity can assume very different meanings for different scientists, and finally «counternormal» behaviour that implies violations of Merton's norms are frequent and often rewarded (Laudan 1982 and Mitroff 1974). Thus CUDOS norms are rather to be considered a means for scientists to position themselves within a precise historical social contract between science and society. Several authors have tried to put Polanyi's and Merton's normative visions into a more sociological context, to both modernize and criticize them. The overall result is a significantly more complex scenario, in which autonomy and disinterestedness are not seen as values internalized by the scientific community but ways of positioning within a system of incentives that rewards them (David, 2003, Krimsky, 2006, Lam, 2010, Ziman, 2000). Together with Popperian positivism, these norms serve as an «organizational myth of science» (Fuchs 1993). Obviously, discursive strategies have always been of first importance in the struggles that characterise the scientific field (Bourdieu 2004, p 77, see also Shapin 2008). On the other hand, hackers provide a multifaceted example of a culture attuned to the economic dynamics of the software world made of start-ups, people escaping from academia, corporate networks, garages and computer science departments. Hacker ethic is also composed of a quasi-formalised set of moral norms. For example, Levy (2010) lists elements such as: access to computers should be unlimited and complete, all information should be free, mistrust authority, hackers should be judged by their hacking, not bogus criteria such as degrees, age, race, or position, you can create art and beauty on a computer, computers can change your life for the better.[3] This ethic is historically related to the academic scientists' ethos and is also an important component of contemporary informational capitalism, as I will demonstrate in the next two chapters. Then, I will use the hacker ethic as an analytical tool for underlining similarities and differences between the approach to scientific institutions, corporations, intellectual property rights and antiestablishment critique expressed by the biologists I have included in this study. Pointing out the relationship between scientists and hackers also allows me to make a comparison between open science on one hand, and the history and the political economy of free and open source software on the other. In the following chapters I will make an explicit comparison between hacker ethic, free software and open science, and I will highlight their ambivalent role in digital capitalism and neoliberalism. As Melinda Cooper maintains, the biotech revolution needs to be understood in the larger context of the neoliberal revolution, since they both share an ambition to overcome limits to growth through «a speculative reinvention of the future» (2008, p. 11). Also the history of hacking, computers and software, in fact, is fully

[3] Other works on hacker ethic, and other versions of it, are Best 2003, Himanen 2001, Ippolita 2005, Jesiek 2003, Moody 2001, Raymond 2001

integrated in the history of neoliberalism and in the development of informational capitalism. At the same time, battles around information technologies and intellectual property are part of a tendency towards the democratisation of information societies.[4]

Remixing cultures

Current biologists' cultural material is at first represented by the set of values inscribed in the famous Mertonian norms, the classic 20th century scientist's ethic. These values represent a tool kit or a repertoire scientists can use to build strategies of action. According to Bourdieu, «researchers' strategies are oriented by the objective constraints and possibilities implied in their respective position» (2004, p 35). These strategies also depend on the structure of the field they operate in and on the distinctive dispositions of their habitus. Nevertheless, the strategies they pursue are not intended as conscious plans leaning toward pursuing specific interests, but rather as «persistent ways of ordering action through time» (Swidler, 1986, p. 273). A set of cultural norms supplies «culturally-shaped skills» (p. 275) that render us «active, sometimes skilled users of culture» (p 277). Therefore, cultural frameworks both enable and constrain individual choices and actions. They are limiting but flexible, stable but not static tool kits that actors can reconfigure and into which they can insert new tools coming from different cultures. But they are also resistant tool kits, somewhat rigid that do not allow users to modify and twist them to their liking. Individuals have access «to only a small, not unlimited number of alternative regimes of action and justification coexisting in a state of instability» (Silber 2003, p 430) from which a person can choose a specific configuration of cultural resources. Individuals can re-appropriate cultural competences that originated in a given historical context and modify them to adapt them to new circumstances and use them in new strategies of action. Cultural norms can survive the phenomena that generated them, as in the case of Mertonian ethic surviving the socioeconomic configuration of «academic science» that enabled it. The functioning dynamics of science described by Robert Merton or by Michael Polanyi are still widespread and vital within today's public representations of science even though the world which sustained them has radically changed (see for example Nowotny et al.,

[4] On this ambivalence that I will further analyse in Chapters 2 and 3, see Biagioli 2006, Castells 1996 and 2005, Coleman 2004, Coleman and Golub 2008, Johns 2009, Mattelart 2003

2001, Ziman, 2000). The boundaries between public and private, for profit and non-profit research increasingly blur, and corporate values burst into academic science even if the continuity with the old ethos does not fail. According to Alice Lam, an author who has studied the ethos of contemporary scientists who work on the «fuzzy» boundaries between academy and industry, one should not predict a shift in the work practices of scientists towards an entrepreneurial mode without taking into account the fact that it can happen only «within a strong continuity of the 'old' academic frame as actors mix disparate logics at the blurred boundaries between institutional sectors» (Lam 2010, p. 335).

As Steven Shapin (2008) puts it, «People matter». The personal virtues and the ethos of contemporary scientists are central to understanding their practices and institutional relationships, and they are not merely a matter of public perception unrelated to the material development of science. Thus, scientists matter, since «the history of science is invariably told through the lives of its heroes» (and this work is no exception) or of its rebels, as we will see in the following chapters (Harman and Dietrich 2008, p. 1). Furthermore, in the R&D and entrepreneurial networks where the forces that drive science development and capitalist economy gather, there, where technoscientific futures are made, the role of scientists' personal virtues and personalities reaches its zenith (Shapin 2008). Scientists push science forward and give direction to technoscientific development. And scientists' culture assumes a special role in contexts of crisis and change, like that that characterized the clash between different intellectual property rights approaches, the privatization of genetic information and the emerging open science movement. Ann Swidler suggests «unsettled lives» are moments in which the reprocessing of an already existing culture enables new strategies of action. In a contested arena, cultural models are more explicit and they can directly shape action, influencing chances of success and therefore the opportunities different actors are able to seize. Laurent Thévenot and Luc Boltanski use the expression «critical moments», in which people «realize that something is going wrong (...) that something has to change» (1999, p. 359). The disputes that originate during these breaking points are subject to an «imperative to justify» (Boltanski and Thévenot 2006), namely the need to justify one's actions and to display the reasons behind one's criticisms in a legitimate and generalisable way. It is during those critical and unstable moments that a scientist can mobilize an ethic as a justificatory regime and reconfigure it by inserting new tools coming from different cultures. Thus, in this work, I analyse the role of this emerging and remixed ethic that provides biologists with new tools and strategies of action that can be used to overcome some of the challenges they face during their participation in today's scientific enterprise.

Open, rebel, corporate science

In Chapter 2 I outline the history of open science and of the involvement of biology in a wave of legal, political and societal clashes around the rise of intellectual property rights. Then, on the one hand, I link this phenomenon to the shifts we have witnessed during the last 40 years in the way scientific research is organised, funded and circulated: the socioeconomic configuration of scientific research has become complex and multifaceted, blurring of the boundaries between academic and corporate science and the coexistence of several intellectual property rights approaches. On the other hand, I contextualize open science within the emergence of different innovation modalities, such as open online production, peer-to-peer, social production and the theories that tackle the clash between the rise of informational common goods and the eternal attempts at private appropriation. The goal of Chapter 2 is to include science in the processes through which the circulation, property and management of information and knowledge shape society and capitalism.

In this sense, the relationship I propose between genetics (and genomics) and information and communication technologies is not accidental: biotechnology genesis partially overlaps computer and hacking history. For example, they share common birth places (MIT, San Francisco Bay Area), while the so-called post-genomic biology, subsequent to the announcement of the sequencing of the human genome in 2000, is heavily dependent on hardware (computational power, databases) and software (programs to analyse and extract relevant information from genetic sequences). Information and communication technologies had an important role in the development of genome mapping and sequencing technologies. The informational metaphors that surround genetics (Kay 2000, Keller 2000, Waldby 2000) have shaped scientists' approach to genetics and have had a role in the rise of intellectual property rights in this field.

Switching to the role of scientists' culture and ethic, one of the underlying questions of my work is: who/what is a scientist today? The scientist as a public figure who acts outside institutional structures of scientific publishing such as scientific journals, conferences and workshops to address mass media's general public is a recurrent figure of science history. Furthermore, many scholars have emphasized that the current configuration of technoscience is characterized by more complex negotiations and conflicts between consumers, social movements, enterprises and academic research. Outside the field of Science Studies, this reconfiguration was depicted with very diverse labels: post-industrial society, knowledge society, informational capitalism, reflexive modernization, and so on. However, such diagnoses share some elements, such as the centrality of the media and communication. This has deep implications for public communication of science (Bucchi 1998, Greco 2002, Nowotny et al. 2001). Cultural changes are not merely staged in private spaces. In fact, media are the main arena that allow scientists to show their personalities, moral values and ways of participating in the building of a future that is embedded in the scientific enterprise. Rae Goodell (1977) used the expression «visible scientists» to describe researchers with a high media profile, able to make the first pages of the newpapers and manage their relationship with the press better than other colleagues. These scientists are irreplaceable characters for the contemporary public, since their role is to introduce science directly into the main public arena of industrialised societies: mass media. Studies on the public communication of science and technology have underlined that several images of scientists coexist and circulate in popular culture. These alternative views of scientists can be diverse, opposite, heterogeneous and complex. A scientist can be a genius, a good guy, even a national hero, a dangerous mad scientist, a Victorian gentleman, a bureaucrat, a political activist, a rebel, a rockstar, a nerd, a villain, a maker, a citizen. In Chapter 3 I introduce the figure of the hacker and propose a comparison with the modern scientist in order to build the basis for the analysis I conduct in the following chapters. In particular, I begin by presenting a history of hackers and an analysis of the development, role and importance of the hacker ethic within the more general framework of the so-called *new spirits of capitalism*. These represent an update of the Weber thesis on the cultural and religious foundations of capitalism and tackle the cultural basis of informational, post-industrial, digital capitalism that embodies ideologies of liberation, horizontality, sharing, cooperation and participation. Then I link the cultural traits of the hacker to an analysis of two other characters: the rebel scientist and the profiteer scientist.

Method and case studies

My argument is supported by empirical research based on three case studies distributed across the United States and Italy and located in the postgenomic era, that is the 00s decade, after the announcement and the publication of the sequencing of the human genome in 2000. I selected these cases according to the following selection criteria: First, they are highly mediatized research projects that received attention by the press and produced a huge amount of communication material destined for the general public. Second, the problem of access to and sharing of the data emerged as a crucial public issue in the communication production related to these cases, and they represent, in different forms, innovations and changes of the relationship between open and closed biology. Open science tools such as open databases, open access journals and open platforms for data sharing are used. These biologists operate in different and often opposing institutional settings: one is a scientist working for international public health institutions and with no relation to the life sciences private sector; another is a geneticist known for being the emblem of science's privatization, of corporate invasion of the life sciences, and of the new enclosures on scientific information and knowledge such as patents and secrecy; finally, I studied a community of amateur biologists external to the boundaries of science's formal institutions. I present these cases in a chronological order, from 2003 to 2010.

The first case involves the *Sorcerer II* which is the Craig Venter Institute's research ship that between 2003 and 2007 circumnavigated the planet to collect, sequence and classify marine microbial genomes. The results of the Global Ocean Sampling Expedition were published in open access journals and the data collected were deposited in a open access database, CAMERA. For the first time the «bad boy» of science Craig Venter, famous for embodying a new type of scientist/entrepreneur, used open science tools. For this research project he put together several different types of scientific actors, from Google to the NIH, and from Discovery Channel to multiple universities (Delfanti et al. 2009).

The second case includes Ilaria Capua, an Italian veterinarian virologist, who works within the national public health system. In 2006, during the global avian flu crisis, she engaged in a public clash against the World Health Organisation (WHO) over its policies on restricted access to data. A letter to her colleagues started a debate involving both scientific journals and the general press. Two years later, Capua founded an independent open access database under the umbrella of GISAID (Global Initiative for Sharing Avian Flu Data), and the WHO eventually changed its policies. As a result, she became a famous open access advocate and an example of a «rebel» and «revolutionary» scientist (Delfanti 2011a, Harman and Dietrich 2008, Morange 2008).

DIYbio (Do-it-yourself Biology) is a network of amateur biologists established in 2008. It is now composed of several groups in major US (and European) cities. Their aim is to provide citizen scientists with cheap and open source tools for biological research which is to be conducted outside the boundaries of scientific institutions. In 2010 they started several collaborations with local hacker spaces to set up small labs. DIYbio also launched BioCurious (a biohacker space to be opened in the San Francisco Bay Area) and the OpenPCR project to build a Polymerase Chain Reaction machine under open source principles. In these two years DIYbio has established dialogues with universities, companies, media and the US government.

To examine these cases I collected communicative materials from national and international media, scientific journals and press offices, and analysed data from multiple sources such as journalistic articles, TV interviews, scientific papers, press releases and websites. Then, by means of theoretical and qualitative discourse analysis, I focused on the images of scientists and his/her norms, virtues or ethics. In the case of DIYbio, the media analysis was coupled with a four-month participatory observation on the US West Coast and interviews with several prominent members. I also conducted an in-depth interview with Ilaria Capua and visited her laboratory in Padua. Finally, in addition to media analysis and interviews I analysed the socioeconomic ecologies of these same cases: their economic alliances and scientific collaborations.

A new open science culture

The individual elements I found are not new. Yet their remix is innovative and embodies a new and emerging figure of the scientist, one who uses open science tools more attuned to the current configuration of the relationship between science and society, but who also rebels against bureaucracy and claims independence from academic and corporate institutions. Autonomy, independence and openness coexist with other elements, for example, a radical refusal of interference coming from Big Bio incumbents. Hedonism. The belief that bare information is good per se, as long as it is shared and accessible. The importance of being an underdog. An intense relationship with the media. The rebellion against the mechanisms of scholarly publishing and peer review. In some cases an explicit drive towards profit and entrepreneurship.

Thus, I suggest that these case studies are good examples of a remix between an old culture that is preexisting, accepted, embodied in a complete set of practices and norms and ready to be used, and a more recent ethic linked to several other fields of innovation. The justifications they produce guarantee scientists a fun and fascinating job, while at the same time they work for the common good. The strategies they pursue are often related to the norms of behaviour attributed to the hacker. In this sense, individuals can mobilize ethics when the need for a reconfiguration of different cultures becomes more pressing. Contemporary scientists can still use some cultural elements belonging to the old Mertonian science ethic, since the influence of that culture has survived the social dimension from which it was born. But they often need to remix it with new and different ethical and cultural elements. Using the hacker ethic as an analytical tool has allowed me to highlight some of the elements shared by very diverse types of scientists: one of the biologists I studied belongs to public research institutions, the second is a free rider who drains money from venture capitalists, media companies and public agencies, and the third ones are amateurs external to official science but immersed in a complex entrepreneurial environment. At the same time, the hacker ethic allowed me to indicate important differences in their approach to information sharing, corporate models and institutional settings. The public dimensions of these biologists are related to the current configuration of the relationship between science and society, enterprise, universities and other actors which participate in the making and marketing of contemporary biology.

In conclusion, open biology is not only a tool wielded against the current status quo and against the enclosures represented by secrecy and strict intellectual property rights. It is open circulation of information that has important political consequences, and the role of new media as tools for democracy is an important discourse underlying the whole development of information societies. For example, photocopy machines (or social media websites...) can be seen as a metaphor for an open society when used by the illegal political opposition in an authoritarian country (Dányi 2006). On the other hand, in a world in which openness, freedom from bureaucracies and cooperation are elements that belong to a capitalistic mode of organising labor and production (Barbrook and Cameron 1996, Boltanski and Chiappello 2005, Hardt and Negri 2000), we must rethink any easy commitment to open source as good per se. Thus, the case studies I have analysed are to be considered as part of a shift towards a more open environment for biological research. Open meaning both open to more participation and cooperation and open to a more diverse set of modes of capitalist appropriation.

*** 2**

Forbidden, public, enclosed, free. A history of open science and its political economy

Picture a pasture open to all
Garrett Hardin, 1968

Open science and its historical and economic basis are the main argument of this chapter. Focused on the political economy of the *production of culture*, it will serve as an introduction to the following one, in which I will tackle the *cultures of producers*. After outlining a short history of the emergence and establishment of open science and its crisis due to the new enclosure movement in the late 20th century, I link it with the software realm and the rise of the free software and open source movement. The emergence of free and open source software and their respective social and organizational foundations have been analysed as important factors in the evolution of contemporary information society. In order to highlight the ambiguity and the a-capitalist character of open science, I shortly analyse openness and participation in relation to their role as resistance practices and as parts of a new and emergent form of appropriation by digital capital.

The invention and institution of new and special forms of property are an important part of capitalism's development. Reification is one the processes that allows capital to include more and more things in the realm of property. Intellectual property can be seen as a way of subjugating immaterial entities such as inventions to new property regimes, as it was the case for «genetic capital» thanks, for example, to the rise of property rights for cattle breeders in 18th century Britain, a shift that preceded the application of property rights to genes and genetic sequences (Brewer and Staves 1996). The emergence of a new proprietary regime of science - what has been referred to as the «second enclosures movement» (Benkler 2006) - is then linked to the transformations of late capitalism, call it post-industrial, informational or post-modern (on those distinctions see Kumar 2004) where information and knowledge assume a leading role in profit accumulation. Marx defined primitive accumulation as «the historical process of divorcing the producer from the means of production,» (1990,

p. 875) a process which preceded and made possible the specific mode of production of capital. His examples are the expropriation of England rural population, the enslavement of American natives, and the like. But updates of the Marxist theory have proposed that primitive accumulation appears every time capital needs to find new ways out of a crisis in its mode of appropriation (i.e. Hardt and Negri 2000). Thus the today's new, but still «primitive» accumulation that Marx would probably call the «original sin» of informational capitalism is characterized by enclosures that do not block access to the informational pasture but rather increasingly manage, adjust and control the flux of data and knowledge. In Gilles Deleuze's societies of control (1992), «enclosures are molds, distinct castings, but controls are a modulation, like a self-deforming cast that will continuously change from one moment to the other, or like a sieve whose mesh will transmute from point to point.» Producers are not being divorced from the means of production, which are more and more diffused and used for free cooperation processes – millions of personal computers connected to the Internet – but they certainly are being expropriated from the fruit of that cooperation. Yet the periodic re-creation of capitalism is accompanied by the imposition of the new limits inscribed in a new property form: in the case of biocapitalism, the exploitation of a new «surplus life» (Cooper 2008).

The waves of propertisation that have characterized science depend indeed from different types of property and different modes of appropriation. In this chapter I will retrace the history of open science I outlined in the introduction, highlighting the links between different socio-economic settings that accompanied some phases of modern science and the ethical frameworks scientists were adopting during those same phases. After abandoning the tradition of secrecy that characterised it during the Middle Ages, science has gone through the openness permitted by patronage (either private or governmental) in modern science, the enclosures expressed by the rise of intellectual property rights in the last few decades of the 20th century, and finally the counterattack of new open science movements in early 21st century coupled with new modes of appropriation based on giving, openness and sharing. Gift economy is a paradigm of capitalist accumulation in today's hi-tech, digital, information-based capitalism. These phases, or tides, of openness and closure characterise all history of science as a form of communicative action, a history related to the different ways of appropriating and valorising information and knowledge.

Open science tides

Open science is a method for producing scientific knowledge by spreading its results and opening them up to the revision of the entire scientific community, maximising information and knowledge circulation and sharing. At the opposite extreme, there is a «closed science», a secret one or one in which communication dynamics are limited within the walls of an institution or subject to the payment of a license such as a patent or a copyright. However, the concept of science as a pursuit of «public knowledge,» which today may appear as obvious, is actually the result of complex and stratified social and economic dynamics. In their historical accounts of the rise of modern open science, William Eamon (1990) and Paul David (2003) have emphasised the social dimension of openness. The practices that compose open science, such as disclosure of knowledge, methods and data, peer review, and cooperation are described as fruits of a social process rather than individual choices and predispositions.

Secrets of nature

A relatively recent phenomenon, open science has surfaced in the modern age. In the Middle Ages, science was secret knowledge not subject to public disclosure. A ethic of secrecy encouraged scholars not to reveal their knowledge. The «secrets of nature» were not to be revealed to anybody but to the select few who would have pursued the penetration of those secrets. Obviously, that ethic of secrecy was linked to the political problem of maintaining the social order, for example, the need to contain thinkers who wanted to question the link between religious knowledge and state power. But social and economic factors were also important, such as the role of guilds of engineers and craftsmen which opposed resistance to open communication of technical secrets. Only in the 17th and 18th centuries, as a part of the scientific revolution, open science emerged as a way of considering science as public knowledge, and limits to freedom of inquiry were drastically questioned. David (2003) explicitly defines it as «open science revolution.» Renaissance ideals pushed towards the open circulation of new ideas, and that ethic of secrecy was slowly replaced by a new ethic of making scientific knowledge public and open to scrutiny, also thanks to science patronage and its search for public recognition. But the tradition of forbidden and secret knowledge also clashed against a more productive and fast-accumulating way of searching for the key to the secrets of nature. The Baconian ideal of scientific progress as a progressive and collaborative effort concurred with the shaping of public science: to Bacon, not individual genius but an egalitarian scientific community was at the center of the scientific enterprise. At the end of the 17th century, the newly founded Royal Society helped institutionalising public science by fostering cooperation among scientists and by establishing a system of open communication composed at first of a record book and a correspondence system: free dissemination of knowledge took the center of the stage. Scientists were not alchemists devoted to secrecy anymore, but gentlemen who pursued knowledge as a journey through Nature's wonders and in embryonic, non-bureaucratic institutions. Chris Kelty (2010, see also Dyson 2009) describes Victorian gentlemen with words such as magic, paternalism, wisdom, eccentricity: men (and only men) who worked in a circle of friends, for pleasure and pure knowledge, for exploration and peers' delight. For Steven Shapin, who gives the example of Charles Darwin as a gentleman scientist,

> the integration of science into structures of power and profit was never more than partial in the nineteenth century. The figure of the man of science as an amateur, conducting inquiry without expectation of a remunerated career, did *not* disappear (2008, p. 41-42)

Later, the emergent role of modern state in directing scientific activities was a crucial factor in the establishment of science as an enterprise based on public knowledge coupled with professionalisation and institutionalisation of scientists, with a transition from science as a calling to science as a job. The state was eager to mobilise more resources and apply scientific inquiry on a scale that altered the scope and, most of all, the character of scientific practice. Technological factors were at play in this transformation: as Eamon suggests, the advent of printing was one of the main factors behind the scientific revolution and the shift towards the establishment of open science. The technological innovation represented by print brought with it new economic incentives linked to the emergence of new publics for science. Thus the emergence of a market for printed books made evident that not only reputation and fame, but profit as well, could be had by publishing one's secret knowledge in order to share it with a growing readership (Eamon 1990, p.340).

Yet until World War II, funding for research came either from corporations or charitable foundations, in a modern form of patronage that shaped science's relation with society. Edgar Zilsel (1945) has linked the emergence of the modern concept of scientific progress to the rise of capitalism: the ideal of science as a cumulative, collective and open inquiry was useful for the establishing of modern innovation systems. In that respect, the boundaries between industry and the state quickly became sharper.

The Republic vs. the Realm

In the 20th century, the relationship between open and closed science took a well-known form, strictly tied to the needs of industry and the state. In modern times and university-based research communities, open science was linked to a rather explicit pact between science and the state, one that allowed scientists to autonomously pursue basic inquiry in exchange for the disclosure of their findings to the system of technological innovation represented by private corporations. Two different organizational regimes, co-existent and complementary, were in place. Several scholars have drawn a distinction between two complementary models using two different regimes of knowledge sharing. On one hand, a sphere where science was supported by public funding and private foundations' patronage, and thus was open, accessible and shared. On the other hand, a sphere of scientific research organized and funded by private entities for commercial profit and under proprietary regimes (see David 2003, p.2).

The modern relationship between the open Republic of Science and the proprietary Realm of Technology was ratified by Vannevar Bush's report (1945) on the adaptation of the state's role in driving big military scientific projects during the war towards a new form of state patronage of science. A new social contract between state, research and industry guaranteed the stability of the kind of open science we continue taking for granted today. Freedom of inquiry, together with institutional autonomy and scientists' disinterestedness, were important ingredients of Bush's recipe for scientific progress and, of course, US national prosperity and security after the end of World War II:

> We must remove the rigid controls which we have had to impose, and recover freedom of inquiry and that healthy competitive scientific spirit so necessary for expansion of the frontiers of scientific knowledge.
> Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown. Freedom of inquiry must be preserved under any plan for Government support of science.

On the other hand, and on the sociological side, Robert Merton's norms of communalism, universalism, disinterestedness and organized skepticism portrayed and favoured the role of academic scientists as producers of public knowledge, open to public circulation and public scrutiny (also see Chapters 1 and 3 for a critique of this model). Several authors criticized this sharp separation between academic and industrial science, depicting a scientific system where the practices of these two actors were mixed, often similar, and always complementary. At the same time, many science sociologists denied the importance of Mertonian norms as a description of the scientist's ethos, and instead focused on those norms as an «organizational myth» (Fuchs 1993). Furthermore, in recent times scientific knowledge as a common good was subject to a radical reorganization linked to the increasing blurring between private and public science, the rise of private funding, and the more porous border between industrial and academic science that has been described as Mode 2, Post-academic or Post-normal science in opposition to a «normal» form of organizing scientific research within academic settings (see Gibbons et al. 1994 or Ziman 2000). Even if patent rights have been strengthened and have embraced more kinds of subjects at least over the last century, since the late seventies we have witnessed growing and broad efforts to enforce the use of intellectual property rights to legally protect scientific knowledge. Even though the rise of university patenting had begun in the Seventies (Popp Berman 2008), two events that occurred in 1980 are usually cited as emblematic of this «appropriation shift.» One event was the passage of the Bayh-Dole Act in the US, followed by similar laws in the international context. It allowed the filing of patent applications for the findings of public funded research projects and gave rise to the the explosion of intellectual property offices in universities. And the other was the Diamond-Chakrabarty sentence, which extended patent laws to living material, namely genetically modified bacteria (US Supreme Court 1980). Industry had an active and important role in this shift. As documented by Graham Dutfield (2003), this story is parallel to a continuous expansion of the role of industry in advocating for stronger and broader intellectual property rights in the life sciences. Industry's lobby activity had a leading role in both the Diamond-Chakrabarty trial and the passage of the TRIPS, or Agreement on Trade-Related Aspects of Intellectual Property Rights, in 1986. Furthermore, corporations struggled to strengthen IPRs on living matter and have seen the convergence of industries such as the chemical one, the seed industry, the pharmaceutical sector and finally the biotechnology sector.

As for genomics, one of the first major features of the growing commercialization of this emerging scientific field came in 1991 when Craig Venter, a researcher at the US National Institutes of Health (NIH) announced the he had filed patents on thousands of partial cDNA sequences associated with coding genes. Following the critiques that emerged because of these patent applications, in 1992 Venter left NIH and founded his own, private capital-founded institute, The Institute for Genomic Research (TIGR). In the period from 1996 to 2001, when the first draft of the human genome was completed, again including a prominent role from Craig Venter (see Chapter 4), the rate of patent applications rapidly increased. The «genome gold rush» had begun, as many firms entered «a race to make claims on potentially valuable genes before the full sequence was placed in the public domain» (Martin et al. 2010, p. 151).

Such a way of organizing knowledge production in Mode 2 or Post-academic science has been described also in terms of changes in the values that drive academic research efforts, that become more contaminated by industry goals. For example, as one of the main accounts of the shift between Mode 1 and Mode 2 puts it,

> universities can adopt 'values' from the corporate culture of industry, bringing forth an entirely new type of academic entrepreneur. Conversely, big firms adopt some of the norms of academic culture, for example when they give employees sabbaticals or provide other forms of training possibilities (Gibbons et al. 1994, p. 37).

For John Ziman (2000), the CUDOS values proposed by Robert Merton were challenged by the emergence of a specular set of norms he summarizes in the acronym PLACE: knowledge production becomes *Proprietary*, *Local* (it meets technical needs), *Authoritarian*, *Commissioned* and is based on the role of *Experts* as problem solvers. Thus, according to this vision, science needs to create an active relationship with the different economic, political and social actors that influence and drive its development. The autonomy and economic security that allowed modern science to prosper are not guaranteed unless science is able to gather consensus within society. Finally, a more general turn towards flexible, just-in-time, informatised production is linked to this transformation. A paradigm for research and development linked to information technologies is emerging, one that «increasingly replaces one dominated by the technologies and organisations of mass production and consumption» (Gibbons et al. 1994, p. 125, see also Mattelart 2003 and Kumar 2004). Big Science is replaced by flexible and diverse collectives which include universities, start-ups, foundations, private companies, patients associations, and so forth, and in which intellectual property rights assume an economic and organisational centrality.

Open science, again

After 2001 though, in a descending curve of that appropriation wave, the rate of patent applications decreased significantly, mostly because of the decline of university patenting (Leydesdorff and Meyer 2010). A general decline in the commercial value of this kind of intellectual property is not enough to explain this phenomenon. The business model that was in place before the human genome sequencing, namely the selling of access to databases, often proved to be unsustainable. Firms switched instead to drug discovery and development or to selling services linked to the search within the huge amount of data generated by massive genome sequencing projects. This process was parallel to a social backlash suffered by the main actors of the appropriation shift. Since the nineties, a wave of social, political and legal clashes hit biotechnology. The accusation of betrayal of the social contract between science and society echoed in social movements against «patents on life» and «biopiracy» and was an important part, for example, of the global social movements which arose after the protests held in Seattle in 1999 against the World Trade Organisation (an example of an emblematic text that belongs to that movement is Shiva 1999).

At the same time, new forms of open science have emerged and now coexist with academic capitalism and corporate science (Gruppo Laser 2005, Hope 2008).

And once again, this latest wave of open science practices is linked to the coming of a new medium - the Internet - and to new social configurations. Information technologies have extended the possibilities of producing, sharing and using scientific data and knowledge in open ways. Science, like many other human activities, has experienced the great consequences of the technological revolution based on the Internet. The world of research, which is based on communication and on the exchange of information, now fully exploits the collaborative instruments that are at the core of the production of web contents we know as Web 2.0. Many of these instruments indeed contribute to the changing of the geographic frontiers of research,which are among scientific disciplines and between scientists and other citizens. The past few years have seen the explosion of scientific data publication forms exploiting new IT technologies which have been made available to everyone – in a quick, convenient and free way – the results of research projects. Scientific journals and open access archives are indispensable to online collaborative science, and the data they contain are the raw material the so-called «Science 2.0» is based on.

The movement for open access in scholarly publishing has produced an explosion of several open access journals that have challenged the business model of traditional scientific journals, based on copyright and expensive subscriptions. There is a positive tendency towards open access publishing: according to a recent study, about 20% of scholarly literature published in 2009 is freely available online (Björk et al. 2010). One of the main examples is the nonprofit publishing group Public Library of Science (PLoS), which publishes several online life sciences journals freely accessible by anybody. With its *PLoSOne*,[5] Public Library of Science is also experimenting with a form of *open peer review* of scientific papers which allows the participation of the entire community of researchers: scientists can comment, correct and discuss the work of their colleagues, giving birth to a process of continuous revision of the published articles. Recently, *Nature* (usually a strong critic of the open access model) partially adopted the open peer review model with its *Nature Precedings*,[6] where free comments can help authors fix and adjust their papers before the final submission to the journal. ArXiv[7] is a huge online, open access archive maintained by Cornell University and co-funded by the US National Science

[5] www.plosone.org
[6] http://precedings.nature.com
[7] http://arxiv.org

Foundation where scientists, especially physicists, mathematicians and computer scientists as well as bioinformatics, upload the preprints of their scientific papers. ArXiv has become the standard for publication in many disciplines. The winner of the Fields Medal and the Clay Prize, the Russian mathematician Grigorij Perelman, decided not to publish his article on the Poincaré Conjecture in a journal. The eccentric scientist's decision was not completely unexpected - he also refused to receive the prizes and he resigned from his professorship - but it can be seen as a sign of the importance of online archiving: the accessibility of Perelman's papers is not influenced by its publication in a journal, and they have been cited hundreds of times.[8] Legal methods to promote the collaborative character of science are the focus of the work by Science Commons, a branch of Creative Commons (CC).[9] Science Commons is an example of an effort to apply the copyleft model to scientific data and knowledge by creating licenses that allow users to access, copy, modify and redistribute scientific works or data without paying any royalties to a copyright or patent owner.[10] According to Creative Commons, 10% of the world's entire output of scholarly journals is CC licensed. Public agencies have adopted broad open access policies. The National Institutes of Health's Public Access Policy, for example, states that

> the public has access to the published results of NIH funded research. It requires scientists to submit final peer-reviewed journal manuscripts that arise from NIH funds to the digital archive PubMed Central upon acceptance for publication. To help advance science and improve human health, the Policy requires that these papers are accessible to the public on PubMed Central no later than 12 months after publication.[11]

Other major national and international agencies and institutions have slowly shifted to open data sharing policies, for example, the Human Genome Project Bermuda Rules.[12] In corporate settings we have witnessed the spread of open

[8] http://scholar.google.it/scholar?q=grisha+perelman&hl=it&btnG=Cerca&lr=
[9] A project launched by Lawrence Lessig, Creative Commons writes licenses alternative to copyright. CC licenses tipically allow people to copy, share, and even modify cultural products such as texts, music or images. www.creativecommons.org
[10] http://sciencecommons.org
[11] http://publicaccess.nih.gov/)
[12] http://www.ornl.gov/sci/techresources/Human_Genome/research/bermuda.shtml

innovation models[13] and in the case of life sciences, open sharing of data is slowly but gradually becoming a complementary form of information management. This change is also brought about by the shifts that have meanwhile occurred in the realm of genomics: the largest databases in the world are now open access, and private enterprises sell services linked to the management of raw data. «Open» and «closed» models of data management coexist both in the private and the public sectors. In 2010, the British pharmaceutical company GlaxoSmithKline made publicly available a database containing the structures and pharmacological data for 13,500 molecules that might possibly become new drugs against malaria (Anonymous 2010). According to Janet Hope (2008) open source business models are spreading in the biology sector, and a full-grown open source biotechnology will rise thanks to the convergence of public sector, nonprofit entities and private companies that use open science models.

P2P science

Changes in contemporary science – which are closely linked to the innovations introduced by the use of the web – are complicating the picture. Actually, the very definition of «open science» is at stake because of the emergence and spreading of cooperative Web platforms. Science is increasingly conducted outside the boundaries of scientific institutions. As a communication enterprise, Science 2.0 practices go beyond information and knowledge sharing within scientific communities. Indeed, science is increasingly being produced and discussed by way of online cooperative tools by web users and without the institutionalized presence of scientists. Citizens conduct, discuss and circulate research outside the once called ivory tower of science. Their radical claims for openness and access to scientific knowledge are heating up a debate on the boundaries of contemporary science. On one side, citizens participation science's decision procedures is at stake; on the other, the scientific enterprise itself is changing. These worlds are increasingly engaging in an inter-communication and the frontier between open and closed science should now be reconsidered: can the Web instruments really generate the collaborative non-hierarchical processes among peers that Yochai Benkler (2006) defines «commons-based peer production»? The web, an indispensable resource for contemporary science, is not

[13] For a well-known example of open innovation outside the domain of scientific research see Huston and Sakkab 2006

only a technological instrument, but also a field in which different views on what science is and what its social purposes are collide.

From bits to atoms

Thanks to the Internet, citizen science is becoming more diffused. But it is not just a matter of diffusion: web tools are creating and facilitating new ways for lay people to interact with scientists or to cooperate with each other. Several definitions have been used to describe this phenomenon, such as «citizen science» or «do-it-yourself science» (DIY) - indeed we are not entering a well-established world, but rather an emergent phenomenon still looking for stability. Here, I will use the definition «peer-to-peer» (P2P) science (Delfanti 2010b). According to the P2P theorist Michel Bauwens (2010), P2P science is an attempt at restoring and broadening the lost openness of the scientific enterprise:

> In peer-to-peer science, a group of equipotential scientists and citizens gets together, and, without representative mechanisms, contribute their particular capacities which will assist in the understanding of the particular object of inquiry. Like in peer production generally, the process starts from the free contributory individual, not from a group-based negotiation of interests.

But what happens when lay citizens or nonscientists go online and engage in scientific activities? «Popular science» or «Citizen science» are two traditional ways of defining grassroots science produced outside the walls of laboratories. The history of citizen science can be traced back to the very beginning of scientific knowledge production. See for example *A People's History of Science* by Clifford Conner (2005), which is a long account of lower class innovation from prehistory to computer hackers. Social studies of science and technology include an entire wave of studies on user-led innovation or lay and popular knowledge. Following political traditions we could go back until the 19th century and consider Pëtr Kropotkin and his *Fields, Factories and Workshops* (1996) in which the collectivist anarchist proposed his peculiar vision of integration of manual and brain work, knowledge, and nature against bureaucratic centralisation. But the Internet has changed the way of collecting, sharing and organising the knowledge produced by people — peers — who do not belong to the established scientific community. Obviously it is not just a technical matter. If these emerging practices are still immature and difficult to grasp it is because they are the fruit of the recent convergence of several technical, cultural and social phenomena. The first example is the emergence of a technical and legal infrastructure which enables free online cooperation. The Internet is characterized by horizontal and pervasive diffusion, open protocols and collaborative tools such as Web 2.0, enhanced by open licenses such as Creative Commons or common pools of knowledge which are resources freely available online. Second, we are witnessing the spread of a maker culture ranging from free software to open hardware projects, from hacker communities to open design and community gardens. This layer is where online social production can move «from bits to atoms» and be embedded in material goods. Finally, a political layer: the diffusion of a request for participation in science's dynamics which dates back to the 1960s and which is still growing (i.e. see Jasanoff 2003). The latter is an important topic for science communication, and it was acknowledged by means of a shift towards more participative, multidirectional and inclusive communication practices. This convergence results in the increase in the number of people who can produce or discuss scientific knowledge without any formal recognition as scientists, and the way the Net enables collaborative systems for them to interact and participate in these activities.

A map of P2P science

A personal and partial map of user-led and peer-to-peer science would include very diverse ways of engaging in scientific knowledge production. The first type of P2P science is the online discussion of science. It can be done via web tools such as blogs, independent forums of patients, activists or amateur scientists and social network websites. These spaces can be hybrid forums where citizens talk with scientists, or P2P spaces where non-experts freely have discussions, exchange information and produce knowledge. Other examples are open online encyclopedias such as Wikipedia, where anybody can contribute to a scientific entry without needing any formal qualifications. A final example is open textbooks and notebooks where lay people can contribute to the stabilizing of knowledge.

The second area of P2P interaction with science is represented by data collection, processing and analysis for a centralized institution. This includes the sharing of personal data, for example, websites such as Google Health[14] or social networks for data sharing such as those implemented by personal genomics companies like 23andMe[15] or other providers of medical and health services. In other cases, netizens are asked to give some of their computers' computational time to process data within distributed computing projects. Examples are Folding@home,[16] which analyses protein structure, or the famous SETI@home, devoted to the search for extraterrestrial intelligence.[17] Other types are based on a request for distributed and active participation of the analysis of data that are collected and processed in a centralized way. For example, projects such as Galaxy Zoo, where volunteers are asked to classify galaxies.[18] Galaxy Zoo has produced several scientific papers. Finally, centralized projects ask a distributed network of citizens to collect independent and original data to help researchers. This is the case of the BioWeatherMap Initiative, rooted in a broad network of volunteers.[19]

The third area of user-led science is composed of completely independent and community-driven P2P science projects which design research, perform experiments and analyse data with the support of distributed networks and platforms. One example is CoCoRaHS (Community Collaborative Rain, Hail and Snow Network[20]), in which thousands of volunteers gather rainfall and weather data across the USA. The hobbyist scientists network DIYbio, which attempts to hack biology and promote garage biotechnology, is the subject of Chapter 6 and one of the most important examples of citizen science. MyDaughtersDna is an open platform for the sharing of information about genetic pathologies to researchers, physicians and patients;[21] the Pink Army Cooperative[22] is a non-profit co-op «operating by open source principles» which works on personalized medicine for cancer: «the first DIY pharmaceutical company.»[23]

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[14] www.google.com/health
[15] www.23andme.com
[16] http://folding.stanford.edu
[17] http://setiathome.berkeley.edu
[18] www.galaxyzoo.org
[19] http://bioweathermap.org
[20] www.cocorahs.org
[21] www.mydaughtersdna.org
[22] http://pinkarmy.org
[23] Other accounts and collections of experiences or maps of citizen science are available online, see for example http://p2pfoundation.net/Category:Science, http://scienceforcitizens.net, http://citizensci.com, http://en.wikipedia.org/wiki/Citizen_science

According to Michel Bauwens (2010), an important trend that underlies P2P science «involves important epistemological shifts towards participation» and a more dialogic practice is one of the possible goals of the DIY science movement. Yet this «epistemology of participation» is part of a broader shift that has begun in the software realm (for a study on citizen biology as a site of public participation also see Kelty 2010). In this sense, the open and distributed structure used by P2P websites and networks such as eMule or PirateBay is just a metaphor for a horizontal, non-hierarchical and cooperative form of production.[24]

Free ~~software~~ science

Beside those claims on the role, scope and results of open science in regard to values such as democracy or participation, what I want to underline is that openness in science is part of a broader movement towards open, horizontal, peer-to-peer production models, both online and offline. A story that began with the rise of free software in the eighties and evolved with the emergence of open source software and the spreading of these production models outside the domain of software. I'm not interested in analysing the technical and legal differences between free and open source software, a much debated issue in the software world and in critical theory which tackles software production. This distinction has of course important political consequences that trace back to the history of free and open source software and the way the communities that produce different types of Free, Libre, Open Source Software (FLOSS) perceive and define their practices. But in the final part of this chapter, I will instead focus on the political economy of these two modes of production, namely their relationship with property, private appropriation, and economic justice.

Free software

Open source refers to a form of property which is not organized around the right to exclude others from a good or a service but rather around the right to use, share, distribute and modify an informational good such as a piece of software code (the source code). This free source code, being «open, public and non proprietary» (Castells 2005) supports the existence of a community of users who are also its developers and sharers. The best known example of FLOSS is of

[24] See the P2P Foundation website, http://p2pfoundation.net

course the operating system Linux, a set of various projects maintained by a community of users and developers thanks to a copyright agreement that guarantees free access to the source code of software such as Debian, Apache or Ubuntu. The Free Software Definition, written by the developer of GNU and founder of the Free Software Foundation Richard Stallman, is one of the main documents that describes how this type of production works:

> «Free software» is a matter of liberty, not price. To understand the concept, you should think of «free» as in «free speech,» not as in «free beer.»
>
> Free software is a matter of the users' freedom to run, copy, distribute, study, change and improve the software. More precisely, it means that the program's users have the four essential freedoms:
>
> The freedom to run the program, for any purpose (freedom 0).
>
> The freedom to study how the program works, and change it to make it do what you wish (freedom 1). Access to the source code is a precondition for this.
>
> The freedom to redistribute copies so you can help your neighbor (freedom 2).
>
> The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.[25]

The famous meaning of «free», as in free speech and not as in free beer, is the basis of the organizational system of free software projects: openness to participation in the community, data transparency (the source code), freedom to share, use and modify code. In order to analyse the link between this model and the scientific enterprise, I want to underline that the FLOSS model is not confined to the software domain. Yochai Benkler, in one of the most known works on peer production, maintains that «the rise of effective, large-scale cooperative efforts - peer production of information, knowledge, and culture» is typified by the emergence of free and open-source software, but at the same time this model is expanding way beyond software production, practically into every domain of information and culture production. Among the most typical examples one can list encyclopedias, entertainment, news or textbooks.

Furthermore, peer production needs to be analysed at very different levels. According to Benkler, there are three functions of mediated communication. The first of which is the physical layer - material technologies - and is comprised of

[25] http://www.gnu.org/philosophy/free-sw.html, accessed January 2011

computers, phones and wires. The second is the logical layer, or the algorithms and standards, which includes software used by machines to store, process and transmit information. And finally there is the content layer - the language meaningful to human beings. In recent years, open source and free software models have spread to all these layers and to almost every possible domain of knowledge production. Today we are witnessing the use of open source models in domains as far from software such as hardware, design, politics, money and so on. A famous and successful example in the hardware domain is Arduino, the Italian «open-source electronics prototyping platform based on flexible, easy-to-use hardware and software.»[26]

Free science

As for the scientific field, the FLOSS movement has opened up new forms of online sharing, collaboration and cooperation between researchers. But what is the relation between the free and open source software model and open science? Several authors and scientists have drawn an explicit (and normative) comparison between these two worlds: free and open source practices and open science *must* converge in order to overcome the anti-commons effects brought about by patents, industrial secrecy and copyright, and enhance the cooperative spirit of science (see Benkler 2006, Hope 2008, Stodden 2010b, Willinsky 2005). The modalities of innovation that emerged within the software field would then be spreading in other sectors of research, innovation and knowledge production. According to Benkler, who uses examples such as Public Library of Science and arXiv, peer production models at work in the scientific world are a great example of convergence between the free software methods and a different field of innovation. Benkler offers examples such as PLoS and ArXiv.org in order to explain how this class of commons-based, nonproprietary production solutions to problems is giving birth to a whole area of information production and exchange unhampered by intellectual property. (Benkler 2006, p. 313)

Victoria Stodden supports this position, urging science to adopt a much needed open source approach in which «open code is an important part of this, as much as open data» (2010b). Stodden's proposal is related to reproducibility: a publishing standard which includes analytical tools, raw data and experimental

[26] www.arduino.cc, accessed January 2011. For a list of open, P2P projects see the Open Everything page of the P2P Foundation, http://p2pfoundation.net/Category:Open, accessed January 2011

protocols, giving any scientist the possibility to reproduce a colleague's experiment. The Stanford biologist Drew Endy, a famous actor in the field of synthetic biology and open science, states that «in 15 to 30 years something really interesting will develop between these two poles: FLOSS and synthetic biology.» According to Endy, both companies and individuals will be able to make key innovations outside the walls of universities and corporations thanks to the diffusion of FLOSS models within biology. The most important study on the link between open source and biology is *Biobazaar*, a book dedicated to «the open source revolution in biotechnology» that applies the peer production model to life sciences (Hope 2008). Hope explicitly draws a comparison to FLOSS practices and the life sciences, arguing that «none of the differences between software and biotechnology constitutes an insurmountable obstacle to implementing an open source 'biobazaar'» (p. 189).

For other scholars, the obvious link between free software and science can be exploited the other way around: Mertonian norms of communalism, universalism, disinterestedness and organized skepticism should contaminate the software field. Indeed, free software is also said to be a milieu where Mertonian norms become «goals in practice» (Kelty 2008 p. 271) and where scientists, engineers and geeks are reinventing norms of behaviour. In particular, free software (and copyleft projects such as Creative Commons) are a place where these norms are embodied in technical and legal practices. Money and reputation, both in free software and in the scientific field, would be two different, but related, currencies that participate together in the incentive system that sustains software production (Kelty 2001).

The political meaning of open source

Is free and open source software a tool of resistance against the privatisation of knowledge or an integral part of current digital capitalism? Do we have to consider FLOSS to be a utopia in practice or as a distopian capitalist appropriation? Liberalism, libertarianism and anti-capitalism are all represented by descriptions of free and open source practices. The non-proprietary and non-market system of innovation and sharing envisioned by Yochai Benkler is a liberal utopia, and has positive results for both private corporations (not information incumbents and monopolists though) and grassroots, non-profit projects which are part of a transformation toward more liberal and egalitarian societies. Individuals would radically benefit from a broadening of the commons-based peer production model based on the free software practices. In Benkler's words,

> the practical freedom of individuals to act and associate freely—free from the constraints of proprietary endowment, free from the constraints of formal relations of contract or stable organizations—allows individual action in ad hoc, informal association to emerge as a new global mover. It frees the ability of people to act in response to all their motivations. In doing so, it offers a new path, alongside those of the market and formal governmental investment in public welfare, for achieving definable and significant improvements in human development throughout the world. (Benkler 2006, p. 483)

In her work explicitly dedicated to the open source model in biotechnology, Janet Hope goes further, arguing that software freedom «is a means to an end. That end is free competition.» Open source licenses are «essentially procompetitive: they promote low barriers to entry and dismantle the monopoly powers associated with intellectual property right» (2008, p. 167). On the contrary, in a speech addressed at the World Social Forum in Porto Alegre, Manuel Castells (2005) maintained that open source is an a-capitalist practice that can be adopted by resistant, autonomous communities as well as by private corporations driven by profit. Thus open source is not necessarily anti-capitalist: a claim that might seem obvious but that contradicts many enthusiastic approaches to commons-based software production as a site of subversion of capitalist relations of production. It is very easy to prove that many companies, including very large corporations, practice open source as one of the several possible different approaches to intellectual property. According to Castells, open source «is a-capitalist, meaning that Open Source is compatible with different social logics and values». Yet open source surely represents a new form of information production which, being based on such a peculiar social organization that does not rely on the incentive of profit nor on exclusive rights to use a good, has profound political implications. Open source «may affect the way we think about the need to preserve capitalist institutions and hierarchies of production to manage the requirements of a complex world».

The similarities of the FLOSS movement's discourses and capitalist discourses of flexibility, free market and information flow, have been underlined by several authors who maintain that «the open software movement cannot be entirely dismissed as a significant alternative to digital commodification and techno-capitalism» (Best 2003a, p. 466). The Italian collective Ippolita, which has written extensively on free software and digital capitalism, has a pointed opinion on the difference between free and open source, in which the latter has cannibalized free software inherent anarchism by adapting its highly productive method developed by hacker communities and making it more elastic in respect to commercial needs while respecting the norm of sharing. Thus, open source licenses would ratify the elasticity and flexibility of this method. A betrayal: «open source represents liberal model's victory over the Free software anarchist model: the only preserved freedom is that of the market» (2005, p. 53).

In their analysis of the relationship between different political uses of the FLOSS philosophy, Gabriella Coleman and Benjamin Mako Hill (2004) argue that the political ambiguity of FLOSS goes beyond the lexical ambiguity of the words free or open, and that «the interplay between FOSS philosophy and practices as it travels through multiple social, economic and political terrains may reveal more than (first) meets the eye.» For example, they underline how words such as freedom and openness are appropriated in different contexts by different users of FLOSS practices, such as nonprofit software projects (Debian), technology corporations (IBM) and anti-corporate activists (the Indipendent Media Centers or Indymedia). Free software communities, indeed, are usually not interested in overthrowing capitalist rules but rather in writing good software and not keeping it private or secret. Still, free software can be a nightmare for corporations that use strictly proprietary models. In October 1998, an internal memo leaked from a Microsoft executive, which later became known as «the Halloween documents», was diffused through the Net by the open source advocate Eric Raymond, making known the most powerful software corporation's fear of the Linux operating system. According to the document, free software was a major threat to Microsoft's position in the operating system market thanks to its abilities to mobilize developers and users:

> The ability of the OSS process to collect and harness the collective IQ of thousands of individuals across the Internet is simply amazing. More

importantly, OSS evangelization scales with the size of the Internet much faster than our own evangelization efforts appear to scale.[27]

Monsieur Mauss, adieu!

Openness, giving and participation. In contemporary advanced capitalism, the political economy of these three components of open science and free and open source software - of free science - are embodied in the so-called hi-tech gift economy, in openness as a tool of resistance and in the ideology of participation. Opposite and complex forces drive the role of openness and participation practices in today's capitalism. In order to highlight the main that are relevant to this study, I shall go back to 1922, when Marcel Mauss published his most famous work: *The gift. The form and reason for exchange in archaic societies* (Mauss 2002). In what would become a masterpiece of both the sociological and anthropological traditions, and building upon several studies of «traditional» societies, Mauss argued on the importance of giving for maintaining social structures and building communities, a concept later used by Warren Hagstrom to explain how scientists' sharing of scientific results contributed to a system of reciprocity similar to the traditional one (see Chapter 3).

The gift today

Today, the gift economy anthropological model has been applied to the Internet and to the collaborative web in which anyone can participate in the production and sharing of free content. As a matter of fact, once we buy a computer and we pay a provider to have access to the Net, most online activities are free. We can use free services, such as search engines, mail boxes, social network websites, online newspapers or tourist guides. At the same time we produce content without being payed, for example, when we publish a video, share a band's record in a peer-to-peer network or write a Wikipedia entry. What allows this economy to survive and be sustainable? According to some authors we are facing a Maussian gift economy that creates and feeds new types of communities. That's what Marco Aime and Anna Cossetta propose in their book *The gift in the Internet era*, a pamphlet focused on online cooperation (Aime and Cossetta 2010). Applying Mauss' gift paradigm to the Web, they analyse the phenomenon of

[27] Halloween I, online http://catb.org/~esr/halloween/halloween1.html, accessed January 2011

content production by thousands of individuals who choose to donate their time and abilities to projects from which they will not receive any monetary benefit. Aime and Cossetta use, as a lens to analyse the collaborative Web, the triangle giving-receiving-reciprocating that according to the antiutilitarianist tradition derived from Mauss' work marks the gift. When we produce online, we are giving – producing social bonds and community and accumulating social and symbolic power. Obviously, many famous examples of online collaborative production create bonds and allow the rise of communities not based on making a profit. The emergence of the Web 2.0 has stimulated a wave of studies that tackle online cooperation and study it from both an institutional and political perspective.[28] Some of these communities have proven extremely efficient in creating new products or content that anyone can use for free – think about encyclopedias (Wikipedia), free software (Linux), news (the blogosphere) or restaurant reviews (Yelp). Those projects have become famous examples of open innovation and open production people participate in without a centralised hierarchy or a wage labor system.

Yet the gift theory taken from the Maussian tradition is not a viable general theory of Web 2.0. Even though authors such as Aime and Cossetta underline the differences between the gift as a «total social fact» and the gift online, they miss a crucial dimension of the mechanisms at work on the Internet. The gift, online, corresponds to new and emergent business models. Still unstable and evolving, yet noticeable and relevant. The sharing culture that has grown on the Net now involves huge numbers of people in projects of online voluntary production: the wealth, diversity and productive capacity of those communities is exceptional, and has caused much talk about a new and emerging production paradigm. But antiutilitarianism is not an adequate criterion to understand these phenomena. There are other actors whose practices we must take into account: private companies. The gift is not enough when co-optation, appropriation, clashes between knowledge producers and companies happen on a daily basis within Web 2.0. The Maussian lens is inadequate to understand what we do when we post a video on YouTube, update our Facebook profile or review a book on Amazon. Online, the Mauss' gift anti-utilitarianism is unidirectional: it applies to the users who produce content without being paid, but not to the

[28] Refer to Bauwens 2005, Benkler 2006. For a study specifically focused on open biology see Hope 2008

companies that transformed participation and giving into a business model. Online giving is not complementary to mercantile relationships: it is integral to and indissoluble from them. Open, horizontal, peer-to-peer production models can be interpreted as forms of community creation through giving only if, in the first place, one analyses their relationship with the dynamics of capitalist accumulation.

Hi-tech gift economy

Contemporary digital and informational economy and its model of soft, flexible, horizontal capitalism has subsumed Mauss' gift, in a new primitive accumulation. In the 21st century, gift economy is embodied in the network with its emphasis on access, participation, gratuity, sharing. It has become a new economic model and a new form of appropriation of the value produced by online cooperation (some famous accounts of this shift are Barbrook, 1998, Rullani, 2004, Terranova, 2000, Hardt and Negri, 2000). The currency of these digital potlatchs[29] is not only reputation, status, sociality, community building, or political power. Open source and gratuity are capitalist modes of production, and the rhetoric that surrounds them is often related to free market and technological advancement: even digital piracy can be understood as a business force, both from the strictly economic viewpoint and in regard to its participation in the discourse of «the moral philosophy of digital libertarianism» (Johns 2009, p. 56). On one hand, this is nothing new if, as Armand Mattelart (2003) points out, during every new technological cycle the redeemer discourse of the information society emerges again, and the long history of the free flow of information is strictly related to deregulation and neoliberalism. For Daniel Bell (1973) the post-industrial society would have been based on «cooperation and reciprocity.» Yet on the other hand contemporary digital economy has created new conditions for the exploitation of the flow of information. Open source software corporations such as Sun Microsystem or IBM (Benkler 2006) guarantee everyone access to their codes and they sell their services, training and customizations without adopting a monopolistic management of information. This open source

[29] The traditional ceremony in which indigenous peoples of the Pacific Northwest Coast re-distribute wealth. Potlatch means «to give away» or «a gift». According to Wikipedia, «The status of any given family is raised not by who has the most resources, but by who distributes the most resources,» http://en.wikipedia.org/wiki/Potlatch, accessed January 2011

informational model of capitalism is presented as a crucial instrument for innovation. Other companies, such as social media websites or search engines, harvest the content produced by masses of users, and sell people's personal and social data in order to create advertising revenue. Richard Barbrook's definition for this phenomenon is «Hi-tech gift economy,» an economy where most users see the Internet as a place to work but also to play, love, learn, debate, collaborate with other people without restrictions due to physical distance or copyright, and (more importantly) without the direct mediation of money:

> money-commodity relations play a secondary role to those created by a really existing form of anarcho-communism. (...) In the absence of states or markets to mediate social bonds, network communities are instead formed through the mutual obligations created by gifts of time and ideas. (Barbrook 1998)

Barbrook underlines the impossibility for capital to completely subsume the gift economies it has to exploit and promote. Rather than prospecting either the victory of digital capital or the irreconcilability of capital and gift economy, he outlines the existence of a symbiotic relationship between the anarcho-communism of hackers and corporate capital, a relationship that prevents the potlatch to assume the commodity form. Against the New Left vision on gift economy relations, Barbrook maintains that the commodity and the gift are not always in conflict with each other. They can also co-exist in a form of symbiosis, and each form of organisation of information production and sharing do not harm or supplant the other. In cutting edge areas of digital economy, the hi-tech gift economy «heralds the end of private property», yet what digital capital needs to do is to privatise the gift and manage and enclose the social spaces where free and voluntary cooperation explodes. In this sense, the commodity and the potlatch «remain irreconcilable». In conclusion, then, echoing Marx's grand vision on labor struggles, Barbrook depicts the hi-tech gift economy as a counterforce opposing privatization and enclosing, and at the same time as a crucial component of digital capitalism's dynamics.

Free exploitation

Other authors adopt a more pessimist perspective and analyse the dark side of Internet gift economies: capital's parasitism of the digital commons (Pasquinelli

2008). In her well-known essay «Free labor. Producing culture for the digital economy,» written at the dawn of the Web 2.0 era, Tiziana Terranova draws on Italian Autonomist Marxist tradition to oppose Barbrook's take on the role of gift and participation in the development of contemporary hi-tech capitalism. According to Terranova, the provision of free content by web companies is coupled with the exploitation of free labor, «a trait of the cultural economy at large, and an important, and yet undervalued, force in advanced capitalist societies» (Terranova 2000, p. 33) or, as Marina Levina put it, «excess productive activities that are pleasurably embraced and at the same time often shamelessly exploited» (2010, p. 5). The social factory, the locus of capitalist production after the shift from factories to the whole society according to autonomist thinkers, is now realised within the networks that constitute a form of radical exploitation of the collective intelligence - aka the Marxian «general intellect» or «the ensemble of knowledge (...) which constitutes the epicenter of social production» (Virno 1996 p. 266). The opposition between capital and labor is not merely based on the clash between intellectual property rights and gift economies, but is rooted in the fact that «the provision of 'free labor' (...) is a fundamental moment in the creation of value in the digital economies» (Terranova 2000, p. 36). Furthermore, incorporation, or the process of capital absorbing the fruits of underground subcultures and resistance movements, is not a mere co-optation of an independent culture by capital. Terranova sees it as an immanent process of moving collective labor emerged outside companies into monetary flows and thus of structuring it within production modes and business practices (p. 39).

Terranova's bitter critique of the much-debated liberation potential of gift economies drags the free culture movement into a fate of damnation. The open source movement is explicitly taken as an example of the free labor model, when Terranova states that in the digital economy, exploitation is endemic, and open source, «which relies on the free labor of Internet thinkers, is further evidence of this structural trend within the digital economy» (p. 49).

In conclusion, in this portrait of participation to the dynamics of the Internet, software companies use the free labor provided by open online communities to produce and extract value. Private profit, in online business models, is the fruit of the moral obligation to share, debug, cooperate and microfund, which feeds hi-tech gift economies. Think about the biggest company of the Internet: Google. The incredibly wealthy and huge corporation's slogan is «Don't be evil» and its mission is «to organize the world's information and make it universally accessible and useful».[30] Google famously provides free services and sells eyeballs to the advertisement industry through its personalized ads systems. Google's reliance on gift economies has been tackled and fiercely criticized by the Ippolita collective in their, *The dark side of Google* (2007), a J'accuse against Google's policies on users' privacy, its business models and its role as a new monopolist of information.[31]

Google your genes

But discourses of participation, gratuity, sharing and free labor are ubiquitous in Western societies. Gilles Deleuze called «society of control» (1992) a new phase of capitalism, in which on one hand disciplinary societies and modern enclosures would have been replaced by free-floating control, modulation, and on the other hand, by people's participation, motivation and permanent training. Also, in the technoscientific realm, participation has been criticized as a new form of governmentality (see for example Pestre 2008). In genetics, one interesting example comes again from Google. The normative drive towards online participation forms the basis of the functioning of Google's genomics start-up, 23andMe, founded by Anne Wojcicki and Linda Avey, Silicon Valley venture capitalists and aspiring science entrepreneurs. Wojcicki is the wife of Google's founder Sergey Brin. A company that provides services such as personal DNA testing and direct-to-consumer genotyping, 23andMe has been referred to as a source of ethical dilemmas and ambiguity from the medical and public health viewpoints. Yet in *Googling your genes*, Marina Levina (2010) analyses it from a completely different perspective, one of control society. Through its social network website, *23andWe*, the company connects its customers and urges them to share their genetic and medical information. In fact, 23andMe provides costumers with a personal genetic profile composed of extensive SNPs analysis. People can then use their profiles for ancestry research or for medical reasons: they get to know, with all the ambiguity inherent to these type of genetic testing, their genetic predisposition to dozens of pathologies. Finally, 23andMe costumers are asked to share both this data and information about their health and medical conditions in the company's social media. According to 23andMe, «this new

[30] Google corporate information, http://www.google.com/corporate/, retrieved January 2011

[31] For another critique of Google's practices see Vaidhyanathan 2011

approach lets *you* initiate, advise and participate in research via the Internet» (emphasis mine) and the possible results of *your* participation and sharing is to

> eliminate the need for inefficient recruitment procedures and distribute the cost of genotyping, we believe connecting people with scientists empowers everyone to accelerate the pace of research. (23andMe, quoted in Levina 2010)

23andMe, as Levina maintains, exploits the moral obligation to share, participate and facilitate information flow in order to use users' data in processes and parts of its research activities that would otherwise need paid staff - such as the subjects that pharmaceutical companies hire for testing new molecules and protocols. Levina uses the notion of «free labor» in order to link contemporary personal genomics with social media technologies which enable, push and absorb into their practices social participation and users «gifts» - in this case, individuals' genetic and medical data. Through its social media website and its discourses of participation and inclusion, 23andMe facilitates an active engagement with genetic research. But «while these engagements are presented as narratives of control, freedom, and empowerment, (…) citizen bioscience is enveloped in 'free labor' economy of the network society» (Levina 2010, p. 7).

The circulation of biological information through online communities is created, managed - and expropriated - by private corporations. Users who live within the participation ideology of Web 2.0 are required to share not only their personal data, as in social media websites such as Facebook or Bebo but also biological information, once again the potlatch and the commodity are not irreconcilable. In fact, when new business models coincide with the gift economies based on the imperative to share, the potlatch and the commodity overlap. Biological information becomes a valuable commodity exactly when it flows through the network in order to guarantee «freedom from disciplinary institutions through full participation in the control society» (Levina 2010, p. 5). Thus «citizen bioscience,» Levina's definition of this phenomenon, is somehow the dark side of perspectives such as Paul Rabinow's (1996) «biosociality,» Nicholas Rose's (2006) participation in biological citizenship or Sheila Jasanoff's (2003) politically engaged take on citizen participation and distributed expertise as two of the much needed «technologies of humility.» I will further explore the problem of participation in citizen bioscience in Chapter 6, when analysing the role of a citizen biology project such as the DIYbio network. We now need to focus on the relationship between hacker ethic and science ethic in order to use these concepts as tools to understand the role of a changing scientists' culture in current informational capitalism and biology innovation regimes.

* 3

Hackers, rebels and profiteers. Scientists' cultures and digital capitalism

> *Whoever does not adapt his manner of life to the conditions of capitalistic success must go under, or at least cannot rise*
> *Max Weber, 1905*

From the analysis of the realm of cultural production – the production and sharing of culture in the form of online content, scientific information and knowledge and so on – I will shift to the analysis of the culture of information and knowledge producers. Why do people decide to share information, content and knowledge for free? How do scientists participate in this new political economy of open science? What are the economic and cultural boundaries within which the scientist's job takes place? As I argued in the previous chapters, the Mertonian ethic of open and disinterested science was the expression of a precise social contract of science. To build a new open science we can not merely rely on new technological solutions and on a revival of the 20th century open science culture. New incentive systems and social configurations are at work, and open science has new ways of distributing benefits to those scientists who decide to openly share their knowledge and data. However, throughout science history its communication and publishing systems have always developed in order to respond to the incentives society gives them. What could an updated social contract look like, then, from the viewpoint of scientists' culture? How would they participate in a system that includes private actors, corporations, foundations, citizen science projects, peer-to-peer research and so on?

In order to begin answering these questions and therefore introduce the case studies that compose the second part of this work, in this chapter I introduce the hacker, the hero of informational capitalism. Hacker culture, as I will describe below, is an important drive for contemporary innovation regimes, and is somehow a heir of scientists' culture. My goal is to create a picture of the relationships between these two cultural systems and to link them to the transformations that have occured in the way science is organized, institutionalized and managed. Thus, the first part of this chapter deals with some theoretical problems related to the way the culture of sharing operates in contemporary digital economies. In the second part I present the hacker and the concept of hacker ethic, and then I introduce characters such as the rebel scientist and the scientist/entrepreneur. These two recurring figures have close relationships with hackers, and they clarify the relevance of the hacker ethic in open science.

The new spirits of capitalism

The emergence and diffusion of «hi-tech gift economies» and the participatory, cooperative turn of informational capitalism has a cultural side. The development of new business models and corporate practices relies on, and shapes, a cultural transformation that implies normative drives towards horizontality, participation, cooperation, giving, flat hierarchies, networking and so on. Several authors have indicated a correlation between these transformations and the emergence of new cultures that, drawing from the title of one of the most famous academic accounts of this phenomena, one can call *new spirits of capitalism*. This wave of studies deal with the ideological changes that have accompanied recent transformations in capitalism (Boltanski and Chiappello 2005). Even though not all these authors belong to the Weberian tradition, they share the idea that transformations that involve people's daily practices and cultures have the power to modify, shape and drive the evolution of capitalism. But they differ when it comes to illustrate the relationship of cause and effect between cultural and material transformations, and regarding the role of those transformations in opening up new possibilities for anticapitalist and liberation struggles. In this paragraph I will build the basis for a possible comparison between the vocation (the *beruf*) of scientists and their role in the evolution of contemporary capitalism.

Old and new spirits

In his classic study on Calvinism, protestant ethic and spirit of capitalism, Max Weber sustained that ethic was a form of legitimation of socioeconomic structures (2003). Radically differing from Marx, he did not believe that the Calvinist ethos was an ideology produced by economic and productive conditions. According to Weber, culture is neither created by nor dependant from economic structures, and does not completely determine them. The «spirit» exists before modern capitalism: it has appeared in places and times in which capitalist structures were still coming to light.

> Of course, this conception has not appeared only under capitalistic conditions. On the contrary, we shall, later trace its origins back to a time previous to the advent of capitalism. Still less, naturally, do we maintain: that a conscious acceptance of these ethical maxims on the part of the individuals, entrepreneurs or laborers in modem capitalistic enterprises, is a condition of the further existence of present day capitalism. (p. 54)

The diffusion of the protestant ethic, according to which, labor allows individuals to reach «divine glory,» or «the seedbed of capitalistic economy,» as Weber calls it, has caused occidental capitalism's emergence and success. Of course he did not suggest the causal relationship between spirit and capitalism, or between culture and social structures, to be univocal and unambiguous. On the contrary, this relationship is complex and multifaceted: a process of co-evolution in which a pre-existing culture and a productive model can adapt to and reconfigure each other. Calvinism is a model of conduct that gives economic behaviour a high moral meaning, justifying behaviors that would otherwise be put down to greed. For Weber, this is the main point which needs to be analysed and clarified: the origins of the spirit of capitalism outside and before capitalism itself. And not as an individual ethos but as a social phenomena originating in groups and collective movements. As Weber put it,

> In order that a manner of life so well adapted to the peculiarities of capitalism could be selected at all, i.e. should come to dominate others, it had to originate somewhere, and not in isolated individuals alone, but as a way of life common to whole groups of men. This origin is what really needs explanation. (p. 55)

Thus in order to understand the forces behind capitalism's expansion, we need not focus on the origins of monetary capital, but rather on the social diffusion of these cultural traits that constitute its spirit, or the ideology that justifies engagement in capitalism.

Within contemporary sociological debate, a few authors have proposed reinterpretations and renewals of the spirit of capitalism (Boltanski and Chiappello 2005, Castells 1996, Himanen 2001). Following the Weberian tradition, some of these studies have made an attempt at updating and revisiting the relationship between the emergence of a culture shared by a social group and the evolution of capitalism. The «new spirits of capitalism» approach contemporary capitalism, based on information production and exchange, innovation, and flexibility – call it post-industrial capitalism, post-fordism, informational capitalism or cognitive capitalism. This update of the description of capitalist ethos and professional ethics takes into account values such as flexibility, networking, horizontality, giving, cooperation and the likes: values that resonate with the transformations of capitalism I have outlined at the beginning of this chapter and that give people new good reasons for devoting themselves to their work and new sets of moral justifications and normative support for their participation in the dynamics of capitalist accumulation. In *The rise of the network society,* Manuel Castells draws an incomplete yet fascinating picture of the «spirit of informationalism». This spirit is a common cultural code shared in diverse forms by the network enterprise. The latter is the idealtype which is driving the development and dynamics of network society thanks to its new ethical structure and its «cultural/institutional configuration» (p. 211).

Critical cultures

In their momentous work which appeared at the turn of the century, Luc Boltanski and Eve Chiappello (2005) take into account Sixtie's counterculture and its effects on managerial culture and the evolution of capitalism after the end of fordism and industrialism. Their analysis relies upon a study of French cadres, from the influence of 1968 critiques of capitalism, to the late 1990s capitalism's attempts at renewing its ideological and organizational foundations. Their analysis echoes David Harvey history of neoliberalism: a phenomenon partly founded on the appropriation of 1968 ideals of individual freedom turned into a populist culture of consumerism and individual libertarianism. According to Harvey, capital had in fact the power to split off the search for social justice from the 1968 movements' rethoric (2005). Boltanski and Chiappello have indicated the existence of a *New spirit of capitalism* rooted in 1968's libertarian, hedonist and individualist values. Boltanski and Chiappello also update the Weberian theoretical apparatus, giving the spirit of capitalism new roles and new origins. According to them, capitalism now lives on critical cultures. It needs to reconfigure and adapt to them in order to be renewed and to find new ways out of the recurring impasses that block it. This mechanism allows capitalism to incorporate critiques and survive attacks. Indeed, it needs to orientate towards the common good in order to exploit committed engagement, but its own resources are not enough. In order to continuously generate its spirit, capitalism needs enemies, «people whom it outrages and who are opposed to it» (p. 27). It is from its enemies that capitalism can acknowledge and incorporate the mechanisms of justice it need in order to demonstrate it is directed towards the common good. According to Boltanski and Chiappello, if the capitalist system has proved infinitely more robust and stable than its detractors thought, it is also because of its very peculiar way of founding its evolution on the critiques that oppose it. Capitalism, to follow the French authors' view, «mobilizes 'already existing' things whose legitimacy is guaranteed, to which it is going to give a new twist by combining them with the exigency of capital accumulation» (p. 20). Capitalism needs enemies and critiques, different accumulation paradigms, opposing cultures.

But how does the cultural dimension push people to actively participate in capitalist dynamics? According to Weber individual motivations were linked to a religious dimension, while Boltanski and Chiappello attribute to the justification of capitalist behaviour models, also a different motivation: the engagement in capitalist enterprise to serve the common good. Three different typologies of motivations drive a social group towards the adoption of capitalist behaviours. The first being committed engagement in the processes of accumulation as «a source of enthusiasm, even for those who will not necessarily be the main beneficiaries of the profits that are made,» (p. 16) which are based on expectations of autonomy. This motivation

> is focused on the person of the bourgeois entrepreneur and the description of bourgeois values. The image of the entrepreneur, the captain of industry, the conquistador, encapsulates the heroic elements of the portrait, stressing gambles, speculation, risk, innovation. On a broader scale, for more numerous social categories the capitalist adventure is embodied in the primarily spatial or geographical liberation made possible by the development of the means of communication and wage-labour, which allow the young to emancipate themselves from (…) traditional forms of personal dependence. (p.17).

The second motivation is based on an expectation of security for themselves and their children. And thirdly, justifications in terms of the common good that can be defended against accusations of injustice. These justifications are based on «a belief in progress, the future, science, technology, and the benefits of industry» coupled with civic ideals that encompass «institutional solidarity, the socialization of production, distribution and consumption, and collaboration between large firms and the state in pursuit of social justice» (p.18). Attraction and fascination; economic security; and the common good. Together, these three motivations constitute «a justificatory apparatus attuned to the concrete forms taken by capital accumulation in a given period» (p. 20).

Californian hackers

The putting to work of the New Left values of individual freedom and cultural dissent and of the Nineties do-it-yourself culture has been studied also by Richard Barbrook, in particular the case of some forms of gift economy rooted in Internet mechanisms (1998). Barbrook explicitly outlines the relationship between counterculture and computer culture. Indeed, the New Left activists stated that information wants to be free and «were preaching to computer scientists who were already living within the academic gift economy». Abandoning Mauss' gift theory, Barbrook suggests that in the Net economy, «contrary to the ethical-aesthetics vision of the New Left, money-commodity and gift relations are not just in conflict with each other, but also co-exist in symbiosis». Yet unlike the authors linked to the Weberian tradition, Barbrook (with Andy Cameron) describes a betrayal of ideals based on ambiguity and co-optation, and not the classic view on the relations between critical cultures and capitalism's dynamics (Barbrook and Cameron, 1995). The Californian ideology, a merciless portrait of the rise of the Internet industry, is «a heterogeneous orthodoxy for the coming information age» soaked by hackers', baby boomers', capitalists' and countercultures' values that

> promiscuously combines the free-wheeling spirit of the hippies and the entrepreneurial zeal of the yuppies. This amalgamation of opposites has been achieved through a profound faith in the emancipatory potential of the new information technologies. In the digital utopia, everybody will be both hip and rich. Not surprisingly, this optimistic vision of the future has been enthusiastically embraced by computer nerds, slacker students, innovative

> capitalists, social activists, trendy academics, futurist bureaucrats and opportunistic politicians across the USA.

The Californian Ideology allows capitalism to «diversify and intensify the creative powers of human labour» by simultaneously reflecting «the disciplines of market economics and the freedom of hippie artisanship,» by blurring «the cultural divide between the hippie and the organisation man.» According to the missionaries of the Californian Ideology, individualism, anti-bureaucracy, autonomy and do-it-yourself are the cool and hi-tech versions of the moral justifications that compose the spirits of capitalism. Computers and information technologies «empower the individual, enhance personal freedom and radically reduce the power of the nation-state. Existing social, political and legal power structures will wither away to be replaced by unfettered interactions between autonomous individuals and their software. Existing social, political and legal power structures will wither away to be replaced by unfettered interactions between autonomous individuals and their software». The acolyte of the Californian ideology are «McLuhanites» who claim that the government should stay off the backs of the cool and courageous entrepreneurs who drive the computer revolution. Technical solutions and free market will replace bureaucracies and prove to be more efficient. Government intervention is considered an interference with the emergent properties of the new economic and technological forces that, we are told, represent both the future and today's embodiment of the laws of nature.

Within this description, Barbrook and Cameron present the hacker as an asocial libertarian «who is a lone individual fighting for survival within the virtual world of information.» Other studies of hackers and their values underline that hackers are part of a new way of organising labor and production. For example, in their survey on the values of free and open source software developers, Mikkonen, Vadén and Vainio (2007) maintain that in corporate environments traditional hacker values of freedom and sharing have much less importance. Developers may not be interested in issues of copyright and free sharing of software. Anti-capitalist values are seldom present and the old Protestant ethic of work is «striking back»: in communities that produce free or open source software under a corporate umbrella, traditional, «Weberian» values of labour organisation are still in place.

Yet this portrayal of the hacker is different from the one that characterises other studies focused on the hacker ethic as a part of a series of professional ethics that have been interpreted as renewals of the Weberian spirit of capitalism, adapted to the transformations of the information society. According to Pekka Himanen (2001), within the information society hacker ethic challenges the protestant work ethic, and it is «an alternative spirit» characterised by «passion, freedom, social worth, openness, activity, caring and creativity». These authors, who differ significantly on several issues, share a common point of view. According to them, cultural transformations do not only follow social changes, they actively shape the development and transformation of today's capitalism. My goal, then, is to understand how the new culture, whose emergence I point out in this work, is organized, where its historical roots are, and finally how it participates in the shaping of contemporary biology. This culture, following the viewpoint that emerges from the work of the new spirit of capitalism theorists, actively contributes to the production of the capitalist society in which it flourishes. Yet its roots in critical movements, anti-corporate and anti-privatisation practices urge us to rethink the unidirectionality of this perspective. If, as Boltanski and Chiappello argue, critical cultures are vital for the evolution of capitalism towards new ways of organizing production and labour, it is also because of the threats posed by those critiques that force capitalism to permanently move and transform itself. In fact, going back to the core subject of this chapter, the hacker is a complex figure, one that comprises anarchist, neoliberal, and libertarian facets. In the following paragraphs I will propose my interpretation of the main features of the hacker culture. Moreover, I will present two characters that help the understanding of the relationship between hackers and scientists and that I chose to be representative of the cultural transformations I am highlighting. These are the rebel and the profiteer, and are useful tools we can use to better understand contemporary bioscientists and the relationship between their culture, the world of ICTs and software production, and the hacker history and myth.

Hackers

Who are hackers, then, and what is their ethic? The hacker ethic is a contemporary set of values related to innovation and research that participate in the development of contemporary capitalism. For the sake of my analysis, I consider the precepts of a hacker ethic as an analytical tool to understand the new public ethos embodied by the new open science culture I highlight in this study. The hacker is an innovator who has never faced the problem of separation between industry and academy. According to the most widespread mythologies, hackers were born at Massachusetts Institute of Technology. Their ethic, formalised for the first time by Stephen Levy in his famous 1984 book *Hackers: heroes of the computer revolution* (Levy 2010) is a direct heir of 20th century academic scientist's ethic, yet it became detached, becoming more multiform and more attuned to the economic dynamics of the software world, made of start-ups, people escaping from the academy, corporate networks, garages and computer science departments (for an explicit comparison between hacker ethic, free software and open science see i.e. Kelty, 2001 and Willinsky, 2005). The communal ethos of hackers, coupled with values such as free sharing of information and knowledge and peer recognition, resonates with the behaviour of modern scientists' communities. A great example of biologists organized as *ante litteram* hackers is the history of the drosophila experimental group in the post-World War I US. These geneticists used to work collectively and were discouraged from transforming lines of work into their personal domains. In the that research environment, everyone was «meddled in everyone's work all the time, swapping mutants, ideas and craft lore» (Kohler 1994, p. 91, see also Kelty 2008). The drosophila community was driven by strategies of improvisation, and free exchange was a fundamental feature of its productive economy as well as its moral economy: a crucial part of the professional identity of the members of the group.

The hacker ethic

Hacker ethic is not a stable or institutionalised concept or set of norms. According to Stephen Levy, for the first generation of hackers its precepts «were not so much debated and discussed as silently agreed upon. No manifestos were issued. No missionaries tried to gather converts» (2010. p. 27). Thus the main narrations and studies on hackers, their ethic and their history decidedly diverge when it comes to scope, object and results. One important part of the hacker representations is that of the cybercriminal who breaks into closed systems in order to steal money and identities, or in order to disrupt information networks – the cracker. Nevertheless, for the aims of this work I chose to discard that image of the hacker and to focus instead on the self-representations of hackers (not necessarily positive representations though) and their ethic. An ethic composed by «inquisitive intensity, skepticism toward bureaucracy, openness to creativity, unselfishness in sharing accomplishments, urge to make improvements, and desire to build» (p. 37).[32] In this respect, we can highlight some common features. The hacker, born at MIT Artificial Intelligence Lab in the late Fifties and early Sixties, grew under the influence of the American countercultural movements of the Sixties and Seventies (Turner, 2006; on the links with biology see Vettel, 2008) and is not just an independent, curiosity-driven innovator with a proactive attitude towards technology and committed to information sharing. The hacker is also an heretic, a rebel against institutions and bureaucracy, an hedonist who works for fun and to make the world a better place. And yes, the hacker is also a resource ready to be sold to venture capital. Several studies which address the discourses of hacker communities underline their ambivalence in regard to their relationship with capital. According to Kirsty Best (2003b, p. 256) «hackers are not only a fringe element, but an integral part of the dominant social ordering of technology. The challenges they make contest and undermine technological systems from within, by exposing gaps and holes in the fabric of technology» (Best 2003, p.265). Some authors explicitly describe the hacker ethic as a new or alternative spirit of capitalism - the best known example is Pekka Himanen (2001, see above).

Finally, authors openly coming from the hacker world depict this ethic as a tool for resisting digital capitalism. For the collective Ippolita (2005, p. 106) hacker norms of behaviour are ideal ways of relating to technology in an active and non-authoritarian way:

> Let's idealize the hacker: passionate study, self education outside the market, curiosity and exchange with referential communities, broad and variegated networks of relationships. The hacker does not settle for tales, whether truthful or not, but needs to spot the source, touch the fount, the origin. Put his/her hands on it.

Drawing on the history of the first generation of hardware hackers, the kids from the early Sixties who worked on the TX-0 mainframe in the building 26 at

[32] Other works on hackers and their ethics are Best 2003b, Himanen 2001, Ippolita 2005, Jesiek 2003, Moody 2001

Massachusetts Institute of Technology, Steven Levy wrote the first description of their norms of behavior. Levy's book is a celebration of hacking as embodied by the very first group of hero adventurers who made the wonders of the «computer revolution» possible. He was, in fact, describing the hacking culture of the very old school, but his principles have been quoted *ad infinitum* by new generation hackers, as confirmed by Levy's afterward for the 2010 edition of his book. I consider them as emblematic of hacker culture in a general sense. The Hacker Ethic:[33]

* *Access to computers - and anything that might teach you something about the way the world works - should be unlimited and total. Always yield to the Hands-On Imperative!* When the Midnight Requisitioning Committee needed a set of diodes or some extra relays to build some new feature into The System, a few (...) people would wait until dark and find their way into the places where those things were kept. None of the hackers, who were as a rule scrupulously honest in other matters, seemed to equate this with 'stealing.' A willful blindness.
* *All information should be free*: If you don't have access to the information you need to improve things, how can you fix them? (...) In the hacker viewpoint, any system could benefit from an open flow of information
* *Mistrust Authority - Promote Decentralization*. The last thing you need is a bureaucracy. Bureaucracies, whether corporate, government, or university, are flawed systems, dangerous in that they cannot accommodate the exploratory impulse of true hackers.
* *Hackers should be judged by their hacking, not bogus criteria such as degrees, age, race, or position*. Hackers care less about someone's superficial characteristics than they do about his potential to advance the general state of hacking, to create new programs to admire, to talk about that new feature in the system.
* *You can create art and beauty on a computer*. To hackers (...) the code of the program holds a beauty of its own.
* *Computers can change your life for the better*. Surely everyone could benefit from a world based on the Hacker Ethic. (...) If everyone could interact with computers with the same innocent, productive, creative impulse that hackers do,

[33] Adapted from Levy 2010, pp. 27-38

the Hacker Ethic might spread through society like a benevolent ripple, and computers would indeed change the world for the better.[34]

Cracking genes and codes

Obviously, one of the main ingredients - if not the primary one - of hacker myths is the emphasis on «active access to information» promoted and pursued by hackers (Best 2003b). In the 1970s, Capitan Crunch was one of the first *phreakers*, hackers able to break into the American telephone network, and is still today a mythical figure of the hacker iconography. He did not act for money, but for the eagerness to know the codes managing the network, which he revealed to everyone, along with the tricks to use them. Crunch would break into phone systems to learn and explore: «I'm learning about a system. The phone company is a System. Do you understand? If I do what I do, it is only to explore a System. That's my bag. The phone company is nothing but a computer» (quoted in Levy 2010, p. 254). Information is good per se and cracking a code or accessing a system are the hacker's goals.

Thus DNA became «crackable» thanks to its transformation into pure code. The human genome sequencing is an informational milestone in the history of biotechnology and bioinformatics. Although the informational DNA metaphors (the book of life, the code) date back to the origin of modern genetics, many scholars have dealt with the analysis of the role played by the Human Genome Project and by the Celera Genomics of Craig Venter in establishing a model of genetics based on information technologies and in its impact on the practices linked to intellectual property and to the size of the contemporary genomics market (Hilgartner 1995, Kay 2000). Kay maintained that «genomic textuality» had become crucial not only for the scientific development of genomics, but also for its commercial development. Other scholars have analyzed the economic transformations linked to the post-genomic era and the information flows marking it, arguing that it is a new form of biocapitalism where technological and economic links between contemporary genetics and ICT have become stronger (Franklin and Lock 2003, Sunder Rajan 2006). It is also important to stress the deep role, both from the epistemic and socio-economic point of view, played by the «cybernetic turn»: a turn towards the translation of genes and

[34] Other overviews of hacker values overlap Levy's one. In his Rebel Code, a history of the free software and open source movements, Moody (2001) uses terms such as openness, sharing, cooperation, freedom, community, creation, beauty and joy

bodies into code, where informational pattern is privileged over materiality (Hayles 1999, Waldby 2000) and incorporation of information on a biological substrate is only a contingent event. Using Haraway's words (1991, p. 164), «communications sciences and modern biologies are constructed by a common move — the translation of the world into a problem of coding, a search for a common language in which all resistance to instrumental control disappears and all heterogeneity can be submitted to disassembly, reassembly, investment, and exchange».

Join us and share the software

Furthermore, hackers feel a deep hatred against code restrictions: they do not tolerate the prohibitions that prevent people from accessing the information that makes up the program instruction. Sharing is also one of the most important commandments of hacker ethos. Richard Stallman is the hacker (the last of true hackers, according to the Levy's book) that founded the free software movement by writing the operating system GNU - the basis of Linux - and the GNU Public License, precursor of the more famous Creative Commons licenses. In 1984 Stallman resigned from MIT over a controversy on the free sharing of software code. His Free Software Song (Stallman, 1991) goes like this:

> Join us now and share the software;
> You'll be free, hackers, you'll be free.
> Hoarders may get piles of money,
> That is true, hackers, that is true.
> But they cannot help their neighbors;
> That's not good, hackers, that's not good
> When we have enough free software
> At our call, hackers, at our call,
> We'll kick out those dirty licenses
> Ever more, hackers, ever more.
> Join us now and share the software;
> You'll be free, hackers, you'll be free.

For hackers, data enclosure and privatisation might even be considered crimes. During the Seventies, Bill Gates was a member of the Homebrew Computer Club, based in the Silicon Valley, and then new epicenter of the hacker movement. The club was a site for hackers to share information, knowledge, tricks, and... code: something Gates was producing. Bill Gates became the «bad boy» of software in part because of his infamous *Open Letter to Hobbyists*, published in the Homebrew Computer Club Newsletter on January 1976, in which he complained about free circulation of software among the hacker community. Hobbyists were illegally copying and distributing his (and Paul Allen's) Altair Basic (which also thanks to this form of piracy became the *de facto* standard, for Gates' happiness). Yet hackers' reactions were negative: Gates received between three and four hundred letters, and most of them were intensely negative. Stir and disdain shook the hacker community after the publication of the letter, an event later known as «the software flap.» In his letter, Gates went quickly to the heart of the matter:

> Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get payed? (Bill Gates, quoted in Levy 2010 p. 233)

But besides the focus on pure information and open access, hacker ethics is multiform. The hacker is not only an independent, curiosity driven innovator, dedicated to sharing his knowledge, but also a heretic, a rebel against institutions and a resource ready to be sold to venture capital. In the next two paragraphs, I will draw a parallel between some of these characteristics of the hacker and the same feature in the public image and history of the modern scientist – and biologist. They can be rebels and profiteers as well.

Rebels

Autonomy is one of the important frameworks that define modern scientists. The much criticized normative piece of Michael Polanyi famously stated that scientists' autonomy had an epistemological motivation, or it was necessary for science to be more efficient: «any attempt at guiding scientific research towards a purpose other than its own is an attempt to deflect it from the advancement of science» (1962). Governmental and corporate planning was rejected «as antithetical to the very idea of science,» as Shapin puts it (2008, p. 197). An even deeper rejection of authority and planning resided in the the rebel, iconoclast, maverick and heretic scientist as a classic element of the narrations on modern science and biology.

Heretic biology

Revolutionary science is the engine of scientific advancement in Thomas Kuhn's epoch-making book, *The structure of scientific revolutions* (1996). Kuhn introduced sociology in the epistemological approach and attributed paradigm shifts to the effort of young scientists towards the imposition of new ideas over established ones. In a non-academic book, the physicist Freeman Dyson (2006) tells the stories of rebels such as Isaac Newton, Robert Oppenheimer, Richard Feynman and Edward Teller, scientists who built their career on the willingness to not abide by status quo's authority. In a collection edited by Oren Harman and Michael Dietrich (2008) several science historians analyse different figures of *Rebels, mavericks, and heretics in biology*. Iconoclast scientists embody different ways of challenging the status quo, but, as Harman and Dietrich put it, they

> are living testaments to the irreverent existence of free will (and thought) in the face of what might seem, to their more conventional counterparts, necessities or truths in no need of being challenged. (p. 9)

In some cases, rebellion becomes part of the researcher's public image, which then becomes a full-blown «public myth». This is the case of the famous geneticist Barbara McClintock, who combined public iconoclasm and private rebellion (Comfort 2008, Fox Keller 1983). Nevertheless, often the iconoclast becomes an icon when roles switch and the rebel gets full recognition from the scientific community or other communities (in McClintock's case, feminist historians and philosophers, as well as the Nobel Prize committee). Obviously, «even rebels need a framework within which their rebellion will make sense» (Segerstrale 2008, p.297) and rebels without a cause are rarely able to find their way to the top of contemporary science. Richard Lewontin lists elements that we need to take into account when we analyse the success of rebels: for example, scientists need to perform public communication and to struggle for employment, promotions and grants. In a more general sense, their acts of rebellion are directed against social or political power. Indeed, in order to understand these rebellions, one should put them in the context of the social and economic structure that enable people to maintain and propagate their thoughts and their influence. According to Lewontin, «breakers of idols are not smashing mere representations of others' gods but destroying potential rallying points for the collective activity of other sects», thus answering to a social and political, rather than epistemological, need (2008, p. 372).

After all, though rebellion is often «a retrospective self-description» from scientists themselves, «being a rebel even appears to be a strategy to attain and keep power» (Morange, 2008). After all, Polanyi himself argued that scientific dissent is often not directed towards scientific institutions but rather against the interference of other types of authorities, and other authors have argued that absolute autonomy in academic context is a myth, for issues of funding, politics, relations with private firms and so on always condition the scientists' activity (i.e. Krimsky 2003, Shapin 2008). Harman and Dietrich also underline that the rebel scientist can appear both inside and outside the most important scientific institution: the university. Not all rebels must work outside the academy, yet often a rebel scientist has to make a break with their institution and the authority of their peers. The British biochemist Peter Mitchell could not conform with university life and chose to work in his personal research institute, Glynn, and to publish his books for an independent publisher he founded, Grey Books. Amongst biologists, for example, primatologist Thelma Rowell used to explicitly maintain that she had been «always taught to question authority: the more authoritarian it is, the more you question it» (Despret, 2008, p. 351); The great evolutionary biologist William Hamilton

> disliked authority, hierarchy, taboos, organized piety, and the growing dependence of science on profit-seeking industry. He wanted open discussion and disliked suppression of truth. He disliked political correctness and (...) also liked breaking rules, at least in small ways, and liked shocking people's beliefs (Segerstrale, 2008, p. 296)

Despite these beliefs, he spent his entire life looking for sponsors to fund his research projects. Pierre Bourdieu (2004, p. 63), while referring to epistemic (and not institutional) revolutions, highlighted that the revolutionary scientist does not only head towards a scientific victory: there's more at stake. Scientists are sometimes willing to change the rules of the game: «revolutionaries, rather than simply playing within the limits of the game as it is, with its objective principles of price formation, transform the game and the principles of price formation.» Thus, the struggles in the scientific field are ones in which «the dominant players are those who manage to impose the definition of science that says that the most accomplished realization of science consists in having, being and doing what they have, are and do.» (Bourdieu 2004, p. 63). To highlight a more concrete case, Harman and Dietrich (2008, p. 18) conclude their introduction with a perspective on rebellion not from the epistemological viewpoint, but the socio-economic one: in 21st century, new and heterodox ideas could come from highly original and highly rebellious minds, capable to tweak biology's funding system, the online publishing system or the relations between university and industry. In order to revolutionise science, tomorrow's genial intellects will need to change the socio-economic structures of life sciences research rather than simply improve existing knowledge with new revolutionary ideas.

Hulking giants

Hackers, with their search for new, heretic solutions and their distrust for authority, centralised bureaucracies and mainframe computers, are certainly in debt to the tradition of the rebel scientist. If rebel scientists revolt against academic bureaucracies or military command over science, the first generation of hackers struggled against IBM and mainframe computers which were not hackable, for example, the IBM 704 computer on the first floor of building 26 at MIT, a computer hackers used to call *Hulking Giant*. A Hulking Giant was a huge, slow, non-hackable computer, «the inevitably warped outcome of Outside World bureaucracy» (Levy 2010, p. 78). These computers were managed by what hackers used to call a «priesthood», and were difficult to access unless one accepted to deal with the old-fashioned bureaucracy which managed them, people in white lab coats who were in charge of punching cards, pressing buttons and switches. The privileged priests who could submit data to the machine and interpret its answers engaged in a sort of a ritual with their acolytes, who were not granted direct access to the mainframe:

> Acolyte: Oh machine, would you accept my offer of information so you may run my program and perhaps give me a computation? Priest (on behalf of the machine): We will try. We promise nothing. (Levy 2010 p. 5)

A similar priesthood, a «scientific fraternity», defends science's autonomy from external impositions according to Merton. But the hackers' quest for autonomy is deeper. If IBM had its way, according to hackers, the world would be slow, centralized and bureaucratic, and «only the most privileged of priests would be permitted to actually interact with the computer,» people who «could never understand the obvious superiority of a decentralized system.» But on the ninth floor of MIT building 26, the floor where hackers were free to experiment with computers, nobody needed to notify superiors or fill out forms to do The Right Thing: hackers had «no need to get a requisition form. (...) Hackers had power. So it was natural to distrust any force that might try to limit the extent of that power» (pp. 30-31). Later, Microsoft replaced IBM as the enemy of decentralised and open cooperation and innovation. In *The Cathedral and the Bazaar*, Eric Raymond (1999) contrasts the cooperative bazaar model of the open software initiative with the closed and hierarchical cathedral of the Microsoft organization. By keeping its information proprietary, Microsoft obfuscates users' direct relationships with technology. Indeed the hacker often pursues knowledge in a way that is independent from hierarchies and institutions. The only acknowledgment he/she looks for comes from his/her results: to crack a code is a goal in itself, and to prove that your hack works is the only thing you need to validate your work. Hackers want to write good code, not to publish peer-reviewed research papers, and they often value charismatic authority over formal and bureaucratic reward systems (O'Neil, 2009).

We owe it all to the hippies

This anti-bureaucracy attitude was quickly directed not only against Hulking Giants but, more in general, against corporate and nation-state monopoly (Best 2003b and Levy 2010). In fact, the history of computers and hacking has other noble ancestors that explain hackers' rebel roots: radical social movements and Sixtie's countercultures. A new generation of hackers was born in the San Francisco Bay Area around 1968, and its goal was to «bring computers to the people.» These hackers worked in close relationship with the countercultural movements of Berkeley, the free-speech movement, anti-war, antinuke movements and so on. Groups such as the People's Computer Company or PCC wanted to «dissipate the aura of elitism, and even mysticism, that surrounds the world of technology» and the first-generation hackers («Jesuits!» according to the Bay Area hacker Lee Felsenstein(N quoted in Levy 2010, p. 180)) with the dream that «access to terminals was going to link people together with unheard-of efficiency and ultimately change the world» (Levy p. 162- 165). Microprocessors - and thus the birth of the personal computer - were going to «eliminate the Computer Priesthood once and for all» (p. 187). The principle of active access to information «becomes translated into an expanded principle of more generalized (and recognizably democratic) fights for access, whether in response to anti-democratic practices of nation-states or commercial entities» (Best 2003b, p. 273). The title of Fred Turner's book, *From counterculture to cyberculture* (2006), is an immersion in this relationship. Turner traces the roots of cyberculture back to the Sixties, when according to Stewart Brand the personal computer revolution had grown directly out of the counterculture. Turner highlights how, for the figures who bridged the New Left and computer culture, the Eighties cyberculture was in debt to a peculiar political underground:

> Bay area computer programmers had imbibed the countercultural ideals of decentralization and personalization, along with a keen sense of information's transformative potential, and had built those into a new kind of machine (p. 103)

The rebel side of computer culture was soon used as an explicit framework for marketing. In a famous 1984 TV spot for the new Macintosh, Apple depicted computers «as devices one could use to tear down bureaucracies and achieve individual intellectual freedom» (Turner 2006 p. 103).

The origins of the biotechnology industry are also partially rooted in Sixtie's countercultures and Californian social movements. Eric Vettel (2008) reconstructs the history of Cetus, one of the first biotech companies created in the San Francisco Bay Area at the beginning of the Seventies. Vettel highlights how, «whether they conducted experiments, published articles in scholarly journal, or delivered papers at scientific conferences, Cetus employees continued to participate in a peer society that celebrated the most professional aspects of academic research». Furthermore, also thanks to the huge efforts made by social movements and students to change the direction of the then emerging biotech industry, «working in the biotechnology industry was egalitarian, humanitarian, even patriotic.» Some researchers, for example, had problems in dealing with their bosses: the deference they needed to exhibit clashed against the anarchist counterculture of Californian campuses. Indeed, explicit issues of participation and democracy are at stake in hacker and computer culture. Several authors have outlined that political outcomes can develop from these cultures.[35] On one hand, we are talking about a critical culture that clashes against the development of neoliberal capitalism and corporate power. For example, the politicized side of the hacker movement has an explicit epicenter in Italy, where every year since 1998, the national Hackmeeting[36] is held in social centers and squats and combines hacking and social activism - hacktivism. In *A Hacker Manifesto*, Mackenzie Wark (2004) uses hacker ethic as the basis to build a Communist Manifesto-like text against digital capitalism. According to Wark, the hacker class is the potential subject of a new, informational and immaterial class war on the vectors of world information, communication and knowledge. Its interests, opposed to the proprietarian class that owns the fluxes of information and that he calls «vectorial» are at the center of the stage of today's struggles for the freedom from capitalism. According to several authors, though, hacking is essentially ambivalent in its political orientation.

Profiteers

Even though capitalist endeavors and the values of hackers often conflict, the hacker ethic is ambivalent with regard to profit and entrepreneurship. In November 1984, Stewart Brand organised an important Hacker Conference in the San Francisco Bay area, and «two themes dominated those conversations: the definition of a hacker ethic and the description of emerging business forms in the computer industry» (Turner 2006, p. 105). Gabriella Coleman's ethnographic work on hacker and open source communities highlights how hackers' discourses embody liberal values such as free speech, giving birth to a form of «political agnosticism» or «multiple morality». In the perspective of Coleman, FLOSS hackers have given code a political neutrality made material through copyleft licenses. Thus the very ambiguous meaning of the «free» of free software includes ideals such as «individual autonomy, self-development, and a value-free marketplace for the expression of ideas» (Coleman 2004, p. 510). Yet very different actors can mobilize free software meaning and interpret it according to

[35] O'Neil 2009, see also Castells 2005 and Coleman 2004. Chapter 2 includes a discussion of the role of participation and sharing in current digital capitalism
[36] www.hackmeeting.org

their opposite needs: IBM adopts it as part of its neoliberal language, while anti-corporate media such as Indymedia find in it subversive potentialities. Through hacker ethic and FLOSS practices, some can celebrate the cult of the individual, while others may celebrate the collective.[37] Even media piracy can become a business force, and its links with libertarian ideals of distributed creativity and laissez faire suggest that its moral philosophy has «a genealogy that leads not to Stewart Brand and ultimately John Stuart Mill, but to Oliver Smedley and Ronald Coase.» (Johns 2009, p. 56. For a pop perspective on digital piracy see also Mason 2008)

Disinterestedness

There is an ambivalent connection between the hacker ethic and profit, one that echoes the connection between scientists' culture and profit. Recent work in the social history of science have highlighted how the enduring image of uninterested scientists is simplistic, for instance, in money and economic matters. Disinterestedness is one of Merton's norms, yet several authors have criticised the adherence of this norm with the reality of scientists' everyday life and work. Hackers certainly do make money, but should scientists make money as well? On one hand, making money seems to not be part of academic scientist's public culture, or at least there used to be tension between Mertonian norms and industrial counternorms (Eisenberg 2006, Hackett 1990). But is it true that, as maintained by Eisenberg, «even as their research goals and appropriation strategies have sometimes converged, academic scientists have struggled to define their norms and practices so as to distinguish their enterprise from that of their profit-seeking rival» (2006, p. 1029)? Most authors would agree on the fact that in Mode 2 or Post-academic science separation is not at play anymore. According to Alice Lam's study on the relationship between «ivory tower» and «entrepreneurial» scientists, most researchers display hybrid orientations and exploit today's «fuzzy boundaries» between science and business in order to defend and negotiate their positions. Subtle resistance against commercial ethos can appear, but in this complex and fluid picture, the adherence to the traditional norms of science and the entrepreneurial models of corporate research coexist. While some scientist can resist the invasion of commercial science, others

[37] Jesiek 2003, on this ambivalence see also Best 2003b, Coleman and Hill 2004, Coleman and Golub 2008

«partake in the realms of both science and business» showing no signs of any ethical problem (2010, p.309).

In between these two poles there is a range of different intertwining of disinterestedness and business. Even when scientists participate in «cycles of patenting» as a normal part of their professional life, they often perceive it as problematic and need to refer to more traditional values. Or, as Packer and Webster put it, «they have to map it onto their more central activity as professional scientists» in order to conserve ties with their academic sociotechnical competencies (1996, p. 450)

While open sharing practices were never limited to academic science, secrecy, patents and other forms of enclosure were not uncommon in university research. Both systems of managing information and knowledge were broadly used by industrial and academic actors during the 20th century. This sharp boundary between academic culture, driven by Mertonian norms of disinterestedness and profit-driven corporate scientific culture, has never been absolute. The infusion of entrepreneurial values brought by increased privatisation during the last decades of the 20th century was acting on a substrate where the two cultures were, at least, overlapping. First of all, the commitment to the free sharing of knowledge depends on the incentives scientists follow, and so, the idea of science as public and disinterested knowledge is a «social contrivance» (David 2003, p.3). Richard Barbrook insists on economic aspects when he maintains that «in science, the opposition between giving as a form of socialising labour, and commodity was never real» (1998). In this sense he takes Hagstrom's (1966) functionalist viewpoint on the gift exchange within scientific communities to an extreme. Also, commenting on Hagstrom's work, Pierre Bourdieu depicts a scientific field in which «the pressure of external demands threatens the disinterestedness of scientists or, more precisely, the specific interest in disinterestedness» (2004, p. 52). In this sense, disinterestedness is an important part of scientists' culture and the paradigm of gift exchange within science «is based on the obligatory denial interest» (p. 53). Social profit and scientific (symbolic) profit, are inseparable and academic norms are part of this intertwining:

> every scientific choice - the area of research, the method used, the place of publication, the choice (...) of rapid publication of partially verified findings - is

also a social strategy of investment oriented towards maximization of the specific, inseparably social and scientific profit offered by the field (p.59).

The view of the managers

Yet a few years ago, social historian of science Steven Shapin adopted a different perspective: a scientific field where on one hand, the separation between the ethic of disinterest of the Republic of Science and the profit-making, entrepreneurial ethos of the Realm of Technology was not true, and on the other hand, the accumulation of symbolic capital was secondary to economic reasons. In this view, the discussions over the nature and conditions of entrepreneurship are the place were the very idea of science is at stake. According to Shapin, decades before the rise of Mode 2 science, research commodification and academic capitalism, the sharp separation between the norms of the academic scientist and those of his/her profit-seeking antagonist, the industrial scientist, has proven to be for the most part artificial. In *The scientific life. A moral history of a late modern vocation*, Shapin (2008) addresses the image of contemporary scientists, their virtues and vocation, focusing especially on the relationship between industrial and academic science. Who they are, where they come from, and how they represent themselves - those scientists who work on the edge between worlds that we used to consider so separated. In fact, the industrial R&D laboratories and the entrepreneurial networks are places where the forces that drive science development and capitalist economy gather. Nevertheless, the historical dimension of this book dates back to the early 20th century. The author reconstructs the clash between «the view from the tower», or the normative accounts of scientists' ethos written by Mertonian sociology, and «the view from the managers,» a body of studies by organization sociologists who worked for companies with R&D sectors. While doing this comparison, he turns the naïve image that many academic scientists still have about their job upside down. The Ivory Tower of science never existed in the way it was depicted during the 20th century, let alone the complexity of 21st century reconfigurations of science institutions. The difference between the goals of academic science – the truth – and industrial science – profit – is an artificial separation between two worlds which needed different public images but at the same time shared several characteristics. After World War II, publishing practices and intellectual property policies already depended on an ecological business model that, even in industrial settings, was becoming more and more complicated. The industrial scientist was able to publish results in journals and to give talks at conferences, meetings of scientific societies and at panels of peer. Patents were perceived to be tools for communicating results, and within the faster fields of innovation the most important thing was not to maintain secrecy but to be able to stay a step ahead of competitors. Though, Shapin is not arguing that we should throw away any scientific ethos and accept the flatter and poorer view of the scientists as moral ordinary people. But the «managerial ethos» imposed on American – and increasingly on European – universities is at minimum a misrepresentation: late capitalism and its informational and innovative strains are embracing new ways of managing creative people such as scientists – for example, classical practices of open science such as data sharing, anti-hierarchy and open publishing. So, when he writes about the professed altruism or moral virtues of scientists, Shapin is underlining the importance of personal reputation for people who deal with the «radical uncertainty» of the techno-scientifical enterprise in a world where speaking of nature and technology means speaking in behalf of the future as well. The book ends – not coincidentally – with the description of a sunny day in San Diego where 200 scientists, biotech and high-tech entrepreneurs, venture capitalists, intellectual property lawyers and other path-breaking species of the knowledge society ecology are meeting and networking by the beach. Hacking is always a subject of passion, drive and pleasure. As I have discussed elsewhere, the hacker movement is often associated with a discourse that subsumes work as passion. (Levy 2010, p. 270) As for science, fun and passion were indicated by Sixties sociologists such as Lewis Feuer (1963), who in opposition to the Mertonian ideal of science sustained that one of the main motivations of modern science is essentially hedonistic. Shapin persists with this point, highlighting the relationship between «fun and funds» (2008, p. 217) and giving the example of very famous scientists such as James Watson, Richard Feynman, Kari Mullis or Craig Venter. Sure enough, hedonism got along very well with the willingness to make profits and cooperate with private corporations.

To describe something similar to the entrepreneurial ethos of hacker culture, one that mixes openness, fun and anti-bureaucratic activism, Geert Lovink (2007) uses the expression «ideology of the free.» This ideology is embodied by the

Japanese venture capitalist, hacker and cyberactivist Joi Ito,[38] whose image overlaps Olivier Malnuit's «The ten commandments of liberal communist» (2006):

> 1. Give everything away for free (free access, no copyright…); just charge for the additional services, which will make you even richer.
> 2. Change the world, don't just sell the things: global revolution, a change of society will make things better.
> 3. Be caring, sharing, and aware of social responsibility.
> 4. Be creative: focus on design, new technologies, and sciences.
> 5. Tell it all: there should be no secrets. Endorse and practice the cult of transparency, the free flow of information, all humanity should collaborate and interact.
> 6. Don't work and take on a fixed nine-to-five job. Just engage in improvised smart, dynamic, flexible communications.
> 7. Go back to school and engage in permanent education.
> 8. Act as an enzyme: work not only for the market, but trigger new forms of social collaborations.
> 9. Die poor: return your wealth to those who need it, since you have more than you can ever spend.
> 10. Stand in for the state: practice the partnership of companies with the state.

Isn't Google making profits when it, in its hackers' heaven called Googleplex, allows some of its researchers and programmers to dedicate 20% of their time to the development of autonomous and independent ideas? Or Microsoft, when it allows developers to publish their results in academic journals and present them at conferences? Firms with R&D departments (and profit as a bottom line) are often able to put to work the form of socializing knowledge we see as typical of academic science. These companies may «sometimes opt to freely disclose inventions that are patentable» even when they seem «vulnerable to wasteful disruptions» (David 2003, p. 8-9).

In fact, making business, for hackers, is not sanctioned unless it means betraying the openness ethic – as in the case of the *Letter to hobbyists* Bill Gates sent to the Homebrew Computer Club. But sharing is not opposed to business, even though it can be difficult to conciliate openness and profit. When, for several second generation hackers, going into business became The Right Thing, all of a

[38] http://en.wikipedia.org/wiki/Joi_Ito

sudden they had to face the fact that «they had secrets to keep» (Levy 2010 p. 277). But in the end, «the bulk of these hackers fully integrated their skills within the capitalist enterprise system and the burgeoning information economy» (Levy 2010 p. 266), and the same happened to the Silicon Valley generation that gave birth to the personal computer revolution. To collect the capital needed to start Apple, Steve Jobs sold his Volkswagen bus and Steve Wozniak his HP calculator. Hackers had to pay a price though, and this was somehow a re-elaboration of their ethic. According to Levy, «the Hacker Ethic became perhaps less pure, an inevitable result of its conflicts with the values of the outside world» (p. 451). From an opposite viewpoint, the price was the integration of the hacker ethic into corporate culture.

Part II

When it comes to openness, the oppositions commercial/noncommercial, public/private, profit/nonprofit, and so on does not describe the whole context in which free and open source software operate. Is it not the same for open and free science? One of the points authors who have worked on the political significance of hacking, free software and free science often make is that these practices are symptomatic of bigger changes in the relationship between innovation, knowledge and power. Best (2003b, p. 267, see also Kelty 2008) argues that «the balance of power-knowledge has shifted in favor of this new, resistant, knowledge set - and that the real reason for the widespread fear of hackers is that they have outsmarted the traditional authorities in societies.» This does not merely mean that these practices are more effective with regards to innovation. They might often be, but another important factor at stake is their role in developing new social configurations to sustain innovation regimes. The remix of cultures between hacker and Mertonian ethics I point out is interesting exactly because is part of a shift in institutional and social practices that characterize the scientific enterprise in contemporary biology. Hackers, rebels and profiteers serve as my cardinal points to decipher the three cases of open biology I will describe in the following chapters: the open access turn of Craig Venter, the bad boy of entrepreneurial science; the rebellion of Ilaria Capua against bureaucracies and their closed data sharing policies; the network of citizen biologists DIYbio and their attempt at translating the hacker tradition into biology. The use of hacker ethic allows me to point out some similarities, but also different ways of interpreting the transformations linked to the emergence of today's open biology. These cases exemplify the cultural as well as the social shifts biology is witnessing. The elements they bring to light are not only the rise and broadening of open science practices and the relationship between genetics and intellectual property rights. In the stories I will tell in the following chapters, the stage is taken by transformations in the peer review system, public participation in the scientific enterprise, commodification of academic biology, public communication (or rather medialization), and by the crisis of scientific institutions and Big Bio incumbents and the rise of new social spaces for biological research.

*** 4**

What Dr. Venter did on his holidays. Sailing and sequencing the seas of capitalism

In one drop of water are found all the secrets of the oceans
Khalil Gilbran

The Sorcerer II is the highly mediatized and spectacular research vessel operated by the J. Craig Venter Institute (JCVI) that circumnavigated the earth between 2003 and 2006 to collect and classify marine microbial genomes. In this research project, Craig Venter used open access tools for the first time, in order to share data and publish scientific papers. In this chapter, I analyze Craig Venter's public communication activities and strategies, specifically focusing on the images of science and the scientist he proposes: that of an 18th century «savant» and 19th century Victorian naturalist devoted to the exploration of new worlds, and that of the hacker, hero of informational capitalism. Emphasizing his independence from both academy and industry, but building strong alliances with both spheres and with the media, Craig Venter sailed the seas of contemporary biocapitalism and media, interpreting a specific typology of the relationship between science and society, enterprises and universities. Indeed, one of the phenomena we are witnessing in contemporary science is the birth of new hybrid figures such as scientist-politicians and scientist-entrepreneurs who want to be both a part of the academic community as well as other social groups. The approach to intellectual property, secrecy and more generally, to information sharing, has become mixed and complex and the boundary between an academic biology devoted to sharing and disinterestedness and a corporate science based on secrecy and profit making, has proved to be mostly artificial. Furthermore, recent developments such as the rise of a hi-tech gift economy, an economy that is able to extract value from freely circulating information, has changed the way business is conducted in the informational economy. The border between academic and corporate biology has become so thin, with respect to sharing and intellectual property rights practices, that crossing it is no longer a cultural adventure. In this chapter, I show how the American biologist Craig Venter – the bad boy of science, who was used as a symbol of science commodification and aggressive intellectual property rights policies, embodies these changes.

In the Sorcerer II case, Venter shifts from closed to open approaches to data sharing, and, as I suggest, he is only the tip of the iceberg of a new model of science-society interaction, rooted in the spheres of marketing, commercialization and communication. In his voyage, there are important issues of contemporary science at stake, such as secrecy, access, exploration, and the future. Actors such as Nobel laureates, mammoth web companies, wealthy venture capitalists, television producers and millions of genes take the stage in this story. Finally, characters such as the hacker, the entrepreneur and the Victorian natural scientist are depicted in the media portraits of Craig Venter and his boat.

Several scientists make strong use of the media, are entrepreneurs and invest energy in developing links with politics and industry. But few decide to live in as many territories as Craig Venter did, or are able to build public communication practices in which they assemble rethoric blocks coming both from classical elements and typical contemporary leitmotifs. Through the analysis of the relation between the Sorcerer II and the media, I want to show the characteristics of the specific image of «scientist in public» represented by Venter, in particular in relation to his decision to switch to open access tools such as a open access database and open access journals. Furthermore, I will provide evidence that the public communication by Venter is a powerful instrument in the debate on the limitations, opportunities and interests to be favored in today's biology.

Based on data coming from discourse analysis, I draw the attention on the media production linked to the expedition of the Sorcerer II. The event received a wide media coverage and we collected the major international communication production that dealt with the Sorcerer II since the beginning of its voyage in Spring 2003 up to the publication of the first set of results in Spring 2007: my sources include JCVI websites and press releases, but also press articles, TV programs, documentaries, interviews, scientific publications and books.

The Sorcerer II

After his beginnings as a «public» scientist working at the National Institutes of Health, from which he withdrew in 1991, Venter founded TIGR (The Institute for Genomic Research) and Celera Genomics, the private firm that sequenced the human genome in 2000. He became a symbol of a new kind of scientist/entrepreneur, portrayed in the famous photograph published on the cover of Time Magazine, in which he wears a lab coat *and* a suit dress. But the exit from Celera in 2004 and the consequent founding of J. Craig Venter Institute and Synthetic Genomics, Inc., correspond to a new phase in his career, in which Venter switched to more applied research, such as synthetic and personal genomics, and to a new socioeconomical configuration.

The Sorcerer II is part of his focus on synthetic biology and research on biofuel. A 95-foot sloop, designed to be a sports craft and turned into a research vessel, the Sorcerer II was operated by the J. Craig Venter Institute in the Global Ocean Sampling expedition, a circumnavigation of the Earth carried out to collect and sequence the genomes of marine microbial organisms. The ship, funded also by Moore Foundation, US Department of Energy and Discovery Channel, sailed for thousand miles stopping periodically to collect microbial material from the oceans' waters. After a brief expedition into the Sargasso Sea in Spring 2003, the journey of the Sorcerer II set out officially from Halifax, Nova Scotia, on August 2003, wending its way into the Gulf of Mexico, on to the Galapagos Islands, past Australia and to South Africa. The vessel returned to New England in January 2006, after sailing for seventeen months. The samples collected were sent to the Venter Institute of Rockville Maryland for sequencing. With its 6.5 million genetic sequences analyzed and 6.3 billion base pairs catalogued, the expedition created the widest metagenomic database in the world, called CAMERA,[39] and gave birth to a publication in *Science* and a special issue of *PLoS Biology*. The scientific goal of the Sorcerer II mission was to collect and to catalogue an unprecedented quantity of «genes» to be used in synthetic biology projects.

The Sorcerer II expedition was accompanied by a great effort of communication to the general public through different types of mass media. I have identified public communication methods which are common in most part of the contemporary research projects, such as press conferences and press releases, but also direct interaction with the general media such as the case of the documentary shot by Discovery Channel on board of the Sorcerer II (Conover 2005). The website for the expedition contained a tracker allowing users to follow the route of the vessel, informing them on its real-time position. James Shreeve, a *Wired* journalist and biographer of Craig Venter (2004a), went on board of the

[39] http://camera.calit2.net

Sorcerer II to write an article (2004b) published as a cover story in the *Wired* issue of August 2004. The JCVI (2006) presented itself as an institution able to leave the ivory tower to appeal to the citizens, by stating to devote itself not only to the advancement of the science of genomics but also to «the communication of those results to the scientific community, the public, and policymakers», putting research and public communication on an equal footing.

Beyond Darwin

The Sorcerer II mission is explicitly placed in the long tradition of the scientific research voyages, which include, among several, the expedition of the Beagle of Charles Darwin and of the Challenger (Gross 2007 and JCVI 2004b), an oceanographic expedition that circumnavigated the globe between 1872 and 1876, stopping every 200 miles to examine the marine waters searching for unknown organisms, precisely as the Sorcerer II did. Venter himself stated when talking about the *Sorcerer II* in his autobiography, «I found myself in a new yacht, sailing new seas, and seizing new scientific opportunities» (Venter 2007, p. 331). Thus, one of the images of science put forward by the Sorcerer II is the one of the «savant» explorers, scientists who carries out research outside laboratories and the academia. Their enterprises take place within nature in an effort to discover the mightiness and the spectacular features of the universe which coincides with the exploration of the world and the shift in the frontiers of human knowledge. Their dedication to research is all-encompassing and their groundbreaking goals are not only economic, but also scientific ones. The participation of Discovery Channel fell within its Discovery Quest program, an initiative to fund a «new generation of scientific discoveries», as the website of the TV channel maintains. It is about funding forefront «researchers and explorers» (and in the case of Venter the two figures overlap). Their feats should be told so that they can capture the «genius, obstacles and happiness» of moments of revelation so strong that they can «change science» (Discovery Channel 2005). The voyage is not only through nature's secrets, but also a personal adventure, a voyage of discovery *and* «self-discovery» that changes human understanding of the world as well as the scientist's life and understanding of himself (Venter 2007, p. 345).

On 4 March 2004, the Venter Institute held a press conference to present the study published in the *Science* issue of that week, describing the first set of data on the samples collected in the Sargasso Sea. The day after it was in the newspapers all over the world. During the press conference, Craig Venter announced that on that very moment his Sorcerer II, converted into a research vessel, was at the Galapagos islands, spurring journalists to underline the link between his voyage and Darwin's one. The *Wired* headline on the cover explicitly mentioned the most important work by Charles Darwin: «Craig Venter's epic voyage to redefine the origin of the species» (Shreeve 2004b). Also *Science* and *PLoS Biology* highlighted the similarities between the voyage of the Sorcerer II and the Beagle. One of the images published by *PLoS* shows Craig Venter at the Galapagos, posing next to the *Estación cientifica* Charles Darwin. The exploration was associated to the discovery of unknown worlds and to the achievement of wonderful scientific objectives:

> there was obviously an unknown and unseen world in the oceans that could be vital to better understanding diversity on the planet, as well as potentially solving some of the planet's growing environmental issues, such as climate change (Shreeve 2004b).

Likewise, all the narrations on the Global Sampling expedition underlined the comparison with Darwin's voyage, as demonstrated by this excerpt from *Wired*: «He wants to play Darwin and collect the DNA of everything on the planet». Also in the documentary produced by Discovery Channel (Conover 2005) the image of the explorer of new worlds makes an appearance. Craig Venter is examining a map before exploring a tropical island, with the ocean behind his back. Equipped as a scuba diver, he plunges into the waters of the Cocos Island while the voice over says: «Strange things from deep within the Earth are happening […] and Craig Venter is here to investigate». To illustrate the images of the website of the *Global Ocean Sampling Expedition*,[40] there is a quotation from Khalil Gilbran: «In one drop of water are found all the secrets of all the oceans».

A voyage of discovery

However, although the concept of explorer embodied by Venter may seem more imaginative than real-life, his scientific objectives are focused on the most urgent issues of our time: «Craig Venter is starting to wonder if the food we eat and the

[40] www.sorcerer2expedition.org

air we breathe might not come from the place we think», and has embarked on «a global voyage of discovery that might impact you and your neighbourhood's fueling station», as stated by the Discovery Channel documentary (Conover 2005), while the images go from the ocean to a Shell gas station where Venter arrives driving a hydrogen-fuelled car, to fill up the tank with clean and free energy. «Future engineered species could be the source of food, hopefully a source of energy, environmental remediation and perhaps replacing the petrochemical industry» (Venter 2005b). Indeed, bacteria «are the dark matter of life. They may also hold the key to generating a near-infinite amount of energy, developing powerful pharmaceuticals, and cleaning up the ecological messes our species has made» (Shreeve 2004b).

Yet Craig Venter does not limit himself to use and underline the analogy with Charles Darwin, but he wants to go *beyond* Darwin, thanks to the technical instruments he has at his disposal and to his special view of the natural world: «We will be able to extrapolate about all life from this survey. [...] This will put everything Darwin missed into context» (Shreeve 2004b). The enterprise by Venter, indeed, has all the instruments to trace «All life on Earth. And his journey is just begun». Indeed, the Sorcerer II has found «more species in one sample area than Challenger found in its four voyage around the entire planet» (Conover 2005). So, while Venter plunges into the waters of Galapagos and approaches an iguana, the voice over says: «now Craig Venter visits this ecosystem swimming whit Darwin's subjects and collecting life invisibile to the instruments of the 1830s» (Conover 2005). If Darwin's work drove a change in the way we see the world, «Venter is hoping these marine data will do the same in years to come» (Nicholls 2007).

Cracking the ocean code

The images offered by Venter are rich in references to his role of information scientist, another type of explorer of new worlds. I have related the metaphors about the use of information to a special figure who summarizes these characteristics of the public image of Venter: a hacker. Venter embodies different features of the hacker ethic. First of all, his insistence on informational metaphors that go beyond the metaphor of DNA as a code, to explicitly state the direct relationship between genomes and *software code*. Thus, he refers to genomes using computer-related metaphors: «this is actually just a microorganism. […] We need to know his operating system» (Venter 2005b). His objective indeed is to «create the Mother of all databases» (Shreeve 2004b), because «genomes are like software code. Like code, genomes can be mapped» and recorded in a disk: «from life… to a disk», becoming «digital code ready for computer processing» (Conover 2005). Life is genetic information, and the scientist managing to unveil its code using the IT means of contemporary biotechnologies will be able to grasp its secret and to exploit it to the benefit of the entire humankind. Indeed, the hacker is a discoverer of codes, of secrets guarded by coded languages that may turn out to be useful, wonderful, surprising. In the logo used by *PLoS Biology*, the Sorcerer II sails a sea made of A,T, C, G, the initial letters of the four nucleobases that make up the DNA code, and we should «join him in his attempt to change our planet future by cracking the ocean code» (Conover 2005). In the IT jargon «to crack» means to unveil an encrypted code, a metaphor already found in other studies on the public images of biotechnologies (see Davies 2002). Cracking is what hackers do when they violate the access to a system. The ability of hackers, indeed, is based on their skills to manage and manipulate information. Even the Sorcerer II is trying to crack a code that must be unveiled, also without knowing its immediate use. A few years later, Venter was engaged in another research project, the creation of an artificial microbial genome. Venter used his ability to synthesize the genome to launch a hacker challenge to other biologists. Anyone who cracked the code has been invited to visit and send an email to a web address which url is written into the DNA as part of the genetic sequence Venter synthesized (JCVI 2010).

But the hacker metaphors is not related only with cracking information. As in the case of the founding myths of the hackers' world, there is no need to find an application for decrypted codes. «We found 20,000 new proteins that metabolise hydrogen in one way or another. 20,000!»; «We're just trying to figure out who fucking lives out there»; and the genetic code is a «source of power» (Conover 2005) in itself: «If I could boost our understanding of the diversity of life by a couple orders of magnitude and be the first person to synthesize life? Yeah, I'd be happy, for a while» (Shreeve 2004b).

Venter's holidays

Furthermore, in the Craig Venter's voyage, information is depicted as a goal in itself, an adventure experience, and stopping people trying to improve its understanding or acting directly on its mechanism implies a dictatorship. Besides highlighting the importance of «bare» information, in the narration on the Sorcerer II the taste for discovery is mixed with the pleasure of life: hedonism is another typical ingredient of the hacker style. Indeed, the driving forces to a hacker are curiosity and freedom. Their desire for knowledge and self-management in their work makes amusement an important component of their activities, whereas to their eyes bureaucracy and institutions acquire a negative image. When some critics remarked that he should have used a proper and real research vessel, and not his pleasure sailing boat, which «looks and feels pretty much like a luxury yacht» (Shreeve 2004b), Venter replied he wanted to «combine work with pleasure», sarcastically underlining that he «will be joining the vessel very soon to head to French Polynesia. It's tough duty».[41] In fact, the boat was named after the *Sorcerer*, Venter's previous ship, whit which he had won the transatlantic Atlantic Challenge Cup, and which he had sold right before engaging in the Celera challenge to the Human Genome Project. The headline for the article on the Sorcerer published in the *Economist* is: «What Dr. Venter did on his Holidays» (Economist 2007). After all, the expedition left from Halifax in New Scotland because Venter «had never sailed that far north and wanted to see what it was like» (Shreeve 2004b).

Also *Wired*, the magazine that sent a journalist on board of the Sorcerer II, contributes to this image of a scientist. *Wired* embodies the *Californian ideology* (Barbrook and Cameron 1996) of the Silicon Valley, a model of relation between research, technology, society and capitalism born in the garages in which young hackers develop their digital creativity and in the headquarters of the venture capitalists, ready to pour millions of dollars onto innovative projects with a high social relevance. Craig Venter has also had direct contacts with the IT innovation companies. In *Google Story*, David Vise and Mark Malseed tell about the meeting between Craig Venter and Larry Page and Sergey Brin, the two founders of Google. Today, according to Venter's vision, the real challenge of biology is to organize and analyze the huge quantities of data contained in the genetic databases, and «Google's mathematicians, scientists, technologists, and computing power had the potential to vault his research forward» (Vise and Malseed 2006, 285).

[41] Press conference of 4 March 2004, quoted in Pollack 2007

Captain Hook is giving the treasure away

However, hackers also have a business model and a reference market, and Craig Venter is well-known for having adopted secrecy and privatization policies for genetic data. With his Celera Genomics he had challenged the rules of academic science, forcing *Science* to change its publication standards, allowing him to publish the study on the human genome sequencing without making all of the genetic data public. Venter contributed then to the re-definition of the concept of scholarly publishing,

> not so much because of the (old and given) fact that the private sector (with its patents, industrial secrecy etc.) could delay or stop the disclosure of scientific data, but more so, because of the (less known and rather new) fact that the historically important feat of certain scientists could be publicly recognised (and that they could enjoy the ensuing academic prestige), even though all the related data were not freely available to their colleagues (Castelfranchi 2004, p. 2)

In fact, Venter decided to leave *Nature* and publish in *Science*, which guaranteed him the unheard of opportunity to not deposit Celera Genomics' human genome data in GenBank. Instead of following a typically corporate policy, that is to keep data secret without publishing any study, he wanted both scientific recognition *and* industrial secret. It comes with no surprise that, during the Sorcerer II voyage,

> many people are still certain that 'Darth Venter' tried to privatize the human genome, allowing access to the code only to the deep pockets who could afford it (Shreeve 2004b).

But industrial secret, intellectual property rights, and service providing based on open access data are three major modes of making money from biological information. The three are actually crucial in life science today (as well as in software and ITC), but their respective weight changes and oscillates dramatically with time and in different areas. Fear of anti-commons effects, national and international regulation, market demands, and public opinion are some among several factors that influence the choices of what, when and how to appropriate knowledge in life sciences (Mills and Tereskerz 2007).[42]

Indeed, if already while working at NIH Venter was at the center of a furious polemics – NIH having filed in 1991 two patent applications claiming 4 thousands of fragments of human DNA (ESTs), with Venter as the inventor – today he also insist on aggressive patenting tactics: in 2007, while publishing the Global Ocean Sampling Expedition papers in Public Library of Science and its data in the open access database Camera, the JCVI (2007) also filed a patent application for a «minimal bacterial genome». The patent application was so broad that a group of opponents of life patenting, the ETC group, compared Venter with the software corporation famously not prone to openness, Microsoft:

> We believe these monopoly claims signal the start of a high-stakes commercial race to synthesize and privatize synthetic life forms. And Venter's company is positioning itself to become the 'Microbesoft' of synthetic biology. Before these claims go forward, society must consider their far-reaching social, ethical and environmental impacts, and have an informed debate about whether they are socially acceptable or desirable.[43]

Of course, as well as in the case of the Sorcerer II, the issue of making money from information remains at the heart of the scene. Yet Venter has chosen here a different stance, deciding to release all data in the public domain and to publish the main results in *PLoS Biology*, a journal leader of the open-access movement (Pottage 2006, Rai and Boyle 2007). Craig Venter has underlined many times that he intends to produce data anyone can freely explore «from their desktop» and «publicly available to researchers worldwide. [...] No patents or other intellectual property rights will be sought by the Institute on genomic DNA sequence data» (JCVI 2004a).

The pirate ship

Nonetheless, biopiracy accusations came nearly immediately (see Pottage 2006), when Ecuador and French Polynesia, whose territorial waters were crossed by

[42] On secrecy, see Louis et al. 2001; Blumenthal et al. 1996; on anti-commons, Heller and Eisenberg 1998; on the problems posed by the use of information contained in databases for the advancement of science, see Gardner and Rosenbaum 1998.

[43] http://www.wired.com/wiredscience/2007/06/scientists_appl/

the Sorcerer II, opposed the sampling because they feared it was an attempt to exploit their genetic resources. An agreement was reached between the Polynesian authorities and Venter himself after lengthy negotiations with the French government. In the meantime, Craig Venter was criticized with the document *Playing God in the Galapagos* by the non-governmental organization ETC group (2004) and was also nominated by the American Coalition Against Biopiracy (2006) for «Greediest Biopirate», winning the Captain Hook Awards 2006 «for undertaking, with flagrant disregard for national sovereignty over biodiversity, a US-funded global biopiracy expedition» on «his pirate ship». And yet, Craig Venter presented himself as a defender of open access to scientific data, and rejected the biopiracy accusations:

> he's doing everything he can to convince the world that he has no commercial motive: *Here, take it all, I ask for nothing in return*. His generosity has actually exacerbated his political problems. (...) In return for access to their waters, governments expect a piece of the action. But if - like Venter - you are giving everything away, you don't have any benefits to share. 'The irony is just too great,' he says. 'I'm getting attacked for putting data in the public domain' (Shreeve 2004b).

Furthermore, science as a whole was presented as under attack, as well as its path in the progress towards new frontiers of knowledge. In the Venter's discourse, anti-scientific obscurantism occurs when a scientist is forced to «navigate the complex legal territory […] 'If Darwin were alive today trying to do his experiments, he would not have been allowed to,' says Venter» (Nicholls 2007). The comparison with Darwin's voyage is thus publicly used also to reject the accusations on the expedition: «If it's in the Darwin school of biopiracy, then fine» (Nicholls 2007). Here, the future is at stake: «If you do not perceive the possibilities in this shift, if you say *no* instead of *yes*, you will be left in the past. There will be whole societies who end up serving mai tais on the beach because they don't understand this» (Shreeve 2004b). The solution to the problem of the short-sightedness of governments an NGOs that want to defend their genomic and biodiversity resources from the passage of the Sorcerer II lies in Venter's capacity to connect to the world of politics and, when needed, to mobilize it: «He didn't sound too worried. He had already enlisted the French ambassador to the

US to lobby Paris on his behalf, and some top French scientists were writing letters of protest to the ministry» (Shreeve 2004b).

Therefore, Venter's narrative with respect to intellectual property is different here from the one he shows in others strategic fights. This change is also brought about by the shifts occurred in the meantime in the realm of genomics: the largest databases in the world are now open access, and private enterprises rather sell services linked to the management of raw data. Indeed, the business model put forward by Venter is linked to a service economy. While he guarantees everyone access to his codes, he also sells his company's services and know-how. An open source model of capitalism often reappears in the public narrations on the expedition of the Sorcerer II and is presented as a crucial instrument for innovation. Venter's gift economy is embodied in his database, but it is also a tool to form alliances with a very diverse set of funding sources, media and scientific institutions.

In the open ocean

None of the images evoked by Venter are innovative, yet innovative is the recombination Venter makes of them. So, making use of different strata and levels in the complex repertoire of popular imagery on scientists, recurring to several strong metaphors, rethorical tools and discursive leitmotiv, Venter manages to embody multiple figures and stereotypes of a scientists: the «savant» explorer of XVII-XIX century and the hacker of the third millennium, the «amateur», the curious searcher of the truth enacted during the construction of academic science, and the ambitious, proactive, individualist *homo oeconomicus* of the knowledge society. Thus, the hacker Craig Venter fully represents the neoliberal side of open science culture, one dominated by creative destruction and Joseph Schumpeter. The transformation of his data sharing policies is part of his shift towards a more open entrepreneurial environment in which different actors and different forms of intellectual property management coexist. The analysis of the media narrations on his work shows a self-portrait in which an ambitious, brave, restless bio-entrepreneur manages to get free from institutional and bureaucratic constraints typical of twentieth century science, bypassing what is considered as the «classical» figure of a modern scientist: linked to the academia, disinterested, far from mingling with society and the market, belonging to a global scientific community made up of peers. Or rather, explicitly belonging to the industrial research and development, yet external to the stronghold of «high» science: «My greatest success is that I managed to get hated by both worlds», Venter says (Shreeve 2004b). Big Bio scientists are part of a priesthood he wants to defeat with the help of information technologies:

> instead of having a few elitist scientists doing this and dictating to the world what it means, with Google it would be creating several million scientists. Google has empowered individuals to do searches and get information and have things in seconds at their fingertips (Vise and Malseed 2006, p. 286)

Yet these anti-bureaucracy claims are always linked to the ability of raising and managing money from several different classes of funders, such as private companies (Google), governmental agencies (the Department of Energy), nonprofit actors (the Moore Foundation), and even media (Discovery Channel). In the history of computers, hackers have gone as far as to get «dirty money» from DARPA and the CIA (Levy 2010 p. 125), and after all Venter's mixed and complex funding scheme is not that different from the ones that sustained the birth of the computer industry. In Venter's history, anyway, most of the images that include autonomy, entrepreneurship and individualism are hardly new: his withdrawal from the National Institutes of Health in 1991 and from Celera Genomics in 2004 have allowed him to say he does «any kind of science» he wants «without obligation to an academic review panel or a corporate bottom line» (Shreeve 2004b). Venter's science is embodied also by the status of the institutions led by him: on the one hand, the J. Craig Venter Institute, a non-profit organisation, on the other hand the Synthetic Genomics Inc., a company whose aim is to market (and, eventually, patent) the results of research projects on synthetic life. His economic purposes, however, are always made explicit. As *Wired* has reported, being accused of pursuing fame and fortune, Venter «cheerfully agreed».

So in the narrations on this research project, having left academic science and the industrial one aside, the Sorcerer II can finally sail the complex waters of informational economy and of the new economic configuration of life sciences. In its voyage, the ship has embarked, metaphorically or having them installed on board, IT technologies to sequence and to store data, biological machinery, journalists, cameramen, bioinformatics scientists, technicians, public research agencies, universities, startups, biologists, ambassadors, renowned scientists, non-profit foundations, private companies.[44] Contemporary biotechnologies, indeed, require the creation of large and varied hybrid collective groups which make them multidisciplinary, connect them to private and public capitals, and direct them towards the social needs expressed either by semi-public actors, such as foundations, or society in a broad sense (see, for example, Rabinow 1999 and Gibbons *et al.* 1994). Of course, public communication is one of the tools by which these collectives negotiate their interactions. The Sorcerer II case does not represent a break in the norms regulating the production of scientific knowledge, but it is an expression of the changes going through it. Venter is excessive, also and perhaps especially in the case of his vessel: he represents a science turned into a show, highly mediatized, barefaced as regards its objectives and capable of using sophisticated marketing instruments to discuss its work in the public arena, to legitimize it and to give credit to its promises and results. Yet, though excessive and extraordinary, apparently he is not a symptom of an illness in the relation between science and society, but rather an expression of its present physiology in a strategic area of technoscience such as genomics.[45]

Deterritorializing the future

Studying other highly mediatized biotechnologists, although different from Craig Venter, such as Kari Stefansson and James Watson, Michael Fortun (2001 and 2005) has described the promises made by contemporary genomics as speculations on possible future scenarios. Miltos Liakopoulos has dealt with the

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[44] The scientific institutions, public and private ones, appearing in the scientific articles published by Science and PLoS Biology are: J. Craig Venter Institute (JCVI); California Institute for Telecommunications and Information Technology (Calit2); University of California San Diego (UCSD); University of California Irvine; UCSD Center for Earth Observations and Applications; San Diego Supercomputer Center; University of California Davis; Department of Biological Sciences, University of Southern California; Your Genome, Your World; Departmento de Ecología Evolutiva, Instituto de Ecología, Universidad Nacional Autónoma de México; Department of Oceanography, University of Hawaii; Bedford Institute of Oceanography; Smithsonian Tropical Research Institute, Panama; Departamento de Oceanografía, Universidad de Concepción, Chile; Universidad de Costa Rica; Department of Environmental Sciences, Rutgers University; Department of Earth Sciences, University of Southern California; Razavi-Newman Center for Bioinformatics, Salk Institute for Biological Studies; Burnham Institute for Medical Research; University of California Berkeley; Physical Biosciences Division, Lawrence Berkeley National Laboratory; Brown University

[45] E.g. the sequencing and the publication of his own genome, which inspired him to write his autobiography (Venter 2007), or else the production of an artificial microbial genome (Gibson 2008)

public images of the great biotechnological research projects such as human genome sequencing, identifying some recurrent frames into which the most frequent metaphors are grouped. In particular, he highlights the importance of the metaphors linked to the idea of «progress», which present biotechnologies as a revolution that «denotes a sudden break with the status quo and a fast rate of social change that, although dubious about the final effect» announces «the violent change from the pre-existing order into a new, promising era» (2002, 10). Brigitte Nerlich and Iina Hellsten (2004, 266), on the other hand, have defined the presence of metaphors linked to the human genome project as a «treasure» or a «landscape of opportunities» which should be explored: «The metaphors of science as an adventurous journey, in which scientists venture forth onto a new 'plain' […] with their trusted, but now seemingly complete, map in hand» seem to carry the greatest promises of the future of genomics. I could trace all these images of biotechnology also in the public story of the Sorcerer II. Indeed, these are general and hegemonic commonplaces in the discourse of contemporary science. For Micheal Polanyi (1962),

> the Republic of Science is a Society of Explorers. Such a society strives towards an unknown future, which it believes to be accessible and worth achieving. In the case of scientists, the explorers strive towards a hidden reality, for the sake of intellectual satisfaction.

And as Donna Haraway (1988) argues, western science continues to be an important literary genre of exploration and travel. On the other side, as pointed out by Paul Rabinow (1999, p. 17) the argumentation that, with science and progress, our «future is at stake», is crucial in the contemporary narratives, especially in life sciences. Venter seems able to feel the possibilities hidden in such metaphors, and to transform each leitmotiv in an epistemic tool, a powerful political argument, or a marketing trick. During the years in which the voyage of the Sorcerer II took place, Craig Venter was the promoter of other highly mediatized research projects,[5] acquiring credit among the general public as one of the world's most renowned scientists. Yet the scientific and media stage has seen the appearance of other biotechnologists using the same metaphors, exploiting the same images of science, keeping their balance on information disclosure and privatization, and exploiting in the same way the media and the

Internet. Those scholars who have analyzed the discourse practices of post-genomic biotechnologies have underlined the importance of these narrations. Michael Fortun (2001, 145) stated that the value of the new genomics companies are «story stocks» dependent not only on genetic technologies but «on that other set of technologies for simultaneously producing and evaluating anticipated, contingent futures: literary technologies». Also the narrations on the Sorcerer II suggest a scientific, communicative and economic model, as well as a horizon to look at: the future.

Yet other scholars have addressed the Sorcerer II case from a different perspective. Alain Pottage (2006) analyzed its effects in the process of bio-prospecting, focusing on how new types of genetic collections are emerging in the age of bioinformatics and synthetic biology. Deterritorializing genes, that is, displacing them from their role in making living organisms, the Sorcerer is a tool at work in the reconfiguration of current biocapitalism. Stefan Helmreich (2007) argues that Venter's ship role is a means to virtualize oceanic genetic resources in order to create a new, empty territory for capitalist exploration: a new American frontier. In my view, the Sorcerer II enterprise also shows that in some cases this deterritorialization needs genetic information to circulate in open forms. In Venter, this need for a new open frontier mirrored deep transformations of his public ethic. But openness was never ambiguous: it was always related to individual and market freedom.

* 5

Just another rebel scientist. Ilaria Capua and the restoration of the ethic of science

He who guards against the lust and license of the pardon-preachers, let him be blessed!
Martin Luther, 1517

This is the story of a scientist, her rebellion against institutions and her role in the battle over the access to biological information. Ilaria Capua is an Italian veterinary virologist who, in 2006, during the avian influenza crisis, engaged in a clash against the World Health Organization (WHO) and its database access policies. Her rebellion, staged in the media and backed by an important community of researchers, pushed the WHO to change its policies in favour of an open access model. Capua also founded a new open access database under the umbrella of the Global Initiative on Sharing Avian Influenza Data (GISAID)[46] and became a famous advocate of open science, open biology in particular. Through Capua's story, I analyse the role of scientists' public ethic in a context of crisis where relations between researchers, scientific institutions and intellectual property are redefined. Indeed in the first instance, Capua's cultural material is represented by the set of values inscribed in the Mertonian norms, the classic 20th century scientist's ethic. Yet during the events that gave birth to GISAID, Capua updated this old ethos. Thus, in this chapter, I point out a culture that both transforms but also explicitly continues a 20th century scientific ethos: a pre-existing culture that is dynamic and not static. In simultaneously studying the narrations around Ilaria Capua and her practices, I seek to understand how the cultural tool kit at her disposal - the Mertonian science ethic - has been reshaped and adapted so as to give rise to new strategies of action. As I suggested above, during moments of crisis, such as Capua's clash with the WHO, actors must refer to pre-existing cultural models and revise them. In Capua's case, the occasion for reconfiguring the scientists' ethic is the need to restore openness by urging a big international institution to change its data sharing policies. The face of Big Bio that emerges here is one of a mammoth bureaucratic

[46] www.gisaid.org

public institution challenged by a rebel biologist. There is the dream of a new type of open science enabled by the Internet and ICT tools at stake.

The scientist who rebels against authority is a common image throughout history and in the philosophy of science and biology (Dyson, 2006, Harman and Dietrich, 2008, Kuhn, 1996). And how would you start a rebellion if not with a public call to disobedience? That is what the Italian veterinarian virologist Ilaria Capua did in rebelling against the World Health Organisation, eventually forcing it to change its policies on the access to avian flu data and establishing the Global Initiative for Sharing Avian Influenza Data and its EpiFlu database, now one of the main global open access databases for flu viruses. Capua became well-known at an international level during the avian flu crisis of 2005/06, when she clashed with the WHO by urging her colleagues to refuse its policies and calling for a new open access database for the sharing of avian influenza data. In this chapter I want to ask if Ilaria Capua is just another case of a rebel scientist belonging to that tradition or is there something more in her public image and in her practices? In order to answer this question I turned to the media and communication production related to the birth and establishment of GISAID. Ilaria Capua had a major role in the events that preceded and accompanied GISAID's birth which received wide international media coverage. Following an analysis of Ilaria Capua's practices and the history of GISAID's creation, I take a cultural perspective. Based on data coming from discourse analysis, I use the hacker ethic as an analytical tool to interpret some core aspects of the open science culture expressed by Capua. I compare her public virtues to those of the hacker ethic in order to understand whether, and in what way, she interprets a specific and emergent typology of a scientist. My research material is composed of a review of four years of the major Italian and international communication production that dealt with Capua and GISAID beginning with the the letter she sent to her colleagues in February 2006 that was reported by the journal *Science* (Enserink, 2006a), and ending in 2009. My sources include websites, press articles, radio programs, press releases, emails, conference talks, interviews, scientific publications and books, several of them directly written by Capua. I also conducted an in-depth interview with Capua.

Ilaria Capua and GISAID

Ilaria Capua works at the Istituto Zooprofilattico Sperimentale delle Venezie (IZS), an agency within the Italian public health system based in Padua. Her work as a virologist was already nationally and internationally well-known thanks to her role in the vaccine field and to her research activity on avian viruses. In 2001 she developed the DIVA vaccination strategy against avian flu.[47] Before getting involved in the WHO case, she authored or co-authored hundreds of scientific papers, mainly in small-to-medium importance veterinary science journals such as *Avian Pathology*, *The Veterinary Record* or *Avian Diseases*. In 2005, after having already been appointed to several other national and international positions she was nominated Chair of the Scientific Committee of OFFLU,[48] a FAO/OIE[49] agency established to fight avian influenza. Yet Capua became famous globally during the public health - and mediatic - avian flu crisis between 2005 and 2006.

Capua's story begins with a letter. Her lab was a reference center for FAO and OIE, and in January 2006 it found itself needing to deposit data that related to the sequencing of some H5N1 strains (the avian flu virus). One of them was from Nigeria (the very first diagnosis occurred in Africa) and the other from Italy. On February 16th, 2006 Capua sent an email to 50 colleagues urging them to refuse the WHO policy. As a matter of fact, until then the WHO published genetic sequences of the H5N1 virus in a database in which access was reserved for only a few research groups working with the organisation. Other important institutions had by then already established coherent and broad data sharing policies, for example the NIH policy[50] or the Human Genome Project Bermuda Rules,[51] but for several international agencies such as WHO and FAO, no general sharing agreement was in place. According to Capua, virologists and geneticists working on H5N1 should instead deposit their data in the public and open access database GenBank,[52] which collects all publicly available nucleotide sequences, rather than on the WHO database. She put her own data in GenBank on that very day. On March 3rd the news about Capua's stance was published by *Science*,

[47] Acronym for Differentiating Infected Animals from Vaccinated Animals
[48] Network of expertise on animal influenzas, http://www.offlu.net/index.html
[49] Respectively: Food and Agriculture Organization and World organisation for animal health
[50] http://grants.nih.gov/grants/policy/data_sharing/
[51] http://www.ornl.gov/sci/techresources/Human_Genome/research/bermuda.shtml
[52] http://www.ncbi.nlm.nih.gov/genbank/

the first magazine writing about the WHO-H5N1 affair (Enserink, 2006a). A few months prior, in September 2005, a similar critique involved the US Centers for Disease Control and Prevention (CDC), which was being accused of not fully sharing its avian influenza data (Butler, 2005). But the debate had not yet reached the general media. This time, a few days after the publication of her letter, the clash between Capua and the WHO was staged in public through the general media, not just through media directed at a professional public or at a community such as the mailing list ProMed, which was one of the first arenas where the debate took place.[53] Over the course of the following weeks and months, the debate not only involved major scientific journals such as *Science* and *The Lancet*, but also major US opinion-leading newspapers such as *The New York Times*, *The Washington Post* and *The Wall Street Journal*, and magazines such as *Scientific American* and *Seed*. In Italy almost all national newspapers and magazines covered the story (*Il Messaggero*, *Il Corriere della Sera*, *La Repubblica*) together with several magazines such as *Le Scienze* and *Wired Italia*. In addition, *Nature* openly endorsed Capua's decision: «Three cheers for Ilaria Capua» (Anonymous, 2006b).

The heads of the WHO and Capua's colleagues were therefore forced to enter the debate and position themselves. On March 30th, the first group of colleagues openly rallied in support of Ilaria Capua with a letter to *Nature* (Salzberg et al., 2006). In June, following a second letter to *Nature*, US policy makers began to ask for a mandatory open access policy for H5N1 data, similar to databases such as GenBank. In August it was Indonesia's turn: the government of a country heavily affected by the avian flu virus removed all restrictions on access to its data.

Eventually, on August 31, 2006 Ilaria Capua and Peter Bogner, a strategic advisor who had joined her in her effort to build a new database, together with important scientists from the CDC and NIH announced the creation of the Global Initiative on Sharing Avian Influenza Data, «a global consortium (…) that would foster international sharing of avian influenza isolates and data» (Bogner et al., 2006). Their letter, published in *Nature*, was co-signed by 70 scientists and health officials, including six Nobel laureates. GISAID proposed that geneticists, virologists, veterinarians and epidemiologists would agree to share their data by

[53] A «global electronic reporting system for outbreaks of emerging infectious diseases», www.promedmail.org (Accessed September 2010)

depositing them as soon as possible in a major open access database (such as GenBank). After the publication of the letter, Ilaria Capua became a famous scientist and was honored with her profile in *Science* (Enserink, 2006b). Yet her final victory came in January 2007 when the WHO finally adopted a resolution, completely changing its policies by asking member States to «ensure the routine and timely sharing» of flu viruses.

In May 2008 GISAID opened its own open access database in collaboration with the Swiss Institute of Bioinformatics and with the backing of the Swiss and Indonesian governments, the World Organization of Animal Health and other private partners such as The Bogner Organization. GISAID collected data relating to avian flu. And 2008 was the year in which Ilaria Capua was publicly consecrated as a star of global science, both for her role in flu virus research and as a then famous open science advocate. She won a *Scientific American* SciAm 50 Award and was nominated as one of the «Revolutionary minds» of science by the magazine *Seed*. She was also nominated as the «Veterinarian of the year» in Italy and has maintained a high profile in the media by publishing books, giving television and radio interviews and penning editorials.

Revolutionary mind

Almost every narration on GISAID's birth depicts Ilaria Capua as a rebel and a revolutionary. The recurring terms used to describe her story are refusal, rebellion, revolution, blame and challenge. On the contrary, the other side of the battle is labeled with terms such as secret, an old-boy network and a self-elected circle which needs to be broken. Nothing new, if, as I have argued in Chapter 3, the rebel, iconoclast, maverick and heretic biologist is a classic element of the narratives on modern science and biology, and often the iconoclast becomes a public icon. Capua rebels against science's institutions, first of all against the WHO. But she also rebels against publishing and recognition mechanisms that characterize the work of the scientist and the functioning of modern science; she says «no to science's book of etiquette» (Oriani, 2006) and she does that by «slamming her hand on her desk» with her «in-your-face opinions» (Enserink 2006b). «I broke the moulds» (Capua 2009b), she highlights while she launches «an impassioned call» and after she «threw down the gauntlet to her colleagues» (Anonymous 2006a). In December 2008 *Seed* magazine includes Capua in its special issue, nominating her as a «revolutionary mind» and «game changer» of science. *Seed* underlines how Ilaria Capua is not «willing to settle for the status quo» (Anonymous 2008). This is how *The New York Times* replays her mutiny: «a lone Italian scientist is challenging the system by refusing to send her own data to the password-protected archive» (Anonymous 2006a).

Indeed Capua occupies an underdog position. She is an outsider, a woman, an Italian and a veterinarian. She also positions herself as a pioneer who works «behind the scenes» and for whom «the road is all uphill» (Coyaud 2007). Although she does not work in a garage, as the hacker mythology imagines, her starting conditions and peripheral position keep her outside the inner circle of science. After all, the woman scientist as an underdog and rebel in a sexist world is another leitmotiv in the history of science. Yet the narratives around Capua give it a peculiar spin. She is an underdog but several media keep highlighting how beautiful and glamourous she is. Due to the acronym of a vaccinal protocol she invented, they call her Influenza Diva.

> tall and invariably stylishly dressed (...) she also adds an unmistakable element of glamour to often-staid meetings of the international veterinary circuit, a heavily male-dominated world. In Italy she has become something of a media darling, especially after reporters discovered that she's a cousin of Roberta Capua, a former Miss Italy. She has turned down requests for a joint interview with the beauty queen (Enserink 2006b).

Finally, a further feature of hacker ethic is hedonism. Often Ilaria Capua is irreverent. She plays with information and does not look for formal recognition. In August 2006, after the launch of GISAID in the journal *Nature*, Capua commented «I am so happy. I feel that maybe I should quit working and start arranging flowers» (Pearson 2006) And when somebody told her she was going to be included as one of 2008's most important scientists, she answered: «Really? That's weird, I was in the 2007 one». Capua also affirmed «I thought it was spam, since it seemed such an obvious thing for me to do... Can you believe they give you a prize for doing something like that?» (Coyaud 2008), confirming her willingness to mix work and fun.

Antiestablishment revolution

Ilaria Capua takes a moral stance with her rebellion: she argues she is undertaking an «ethical revolution» related to an unavoidable, individual choice:

> I find myself at a crossroads: to become one of the self-elected trustees of science, or to make our data available to the scientific community (Capua 2009b).

Yet Capua does not rise up against an established knowledge system: hers is not a Kuhnian scientific revolution but rather a rebellion against institutions and their policies. The rebel scientist can appear both within and outside the most important scientific institution: the university. Not all rebels must work outside the academy, yet often a rebel scientist has to make a break with institutions and the authority of her/his peers. In the case of hackers, enemies are corporations, which are old, slow and hierarchical bureaucracies that are not transparent and open to public scrutiny and free competition. In most hackers accounts bureaucrats are depicted as hiding behind arbitrary rules in order to avoid transparency and participation. For the first generation of hackers the epitome of evil bureaucracies was a huge company called International Business Machines: IBM, which big mainframe computer were disdainfully called Hulking Giants (Levy 2010).

Corporations privatize creativity and slow down the innovation process. Indeed in the narrations linked to the birth of GISAID, as IBM and Microsoft are to hackers, the WHO is to Ilaria Capua, an institution which shares many traits with big computer corporations. She rebels against WHO and its data disclosure policies and against the priorities of some countries too. In this sense she is an antiestablishment character: «Academic and national pride must not be allowed to slow potential crucial health research» (Anonymous 2006a), for «results are usually either restricted by governments or kept private to an old-boy network of researchers linked to the WHO, the US Center for Disease Control and Prevention, and the FAO» (Anonymous 2006b). Capua asks her colleagues not to give in to «fraternity»'s flattery. Indeed, its priests are member of a «select circle» that one can not freely access and relate to (Enserink 2006a).

Thus, Capua's distrust is not directed towards fellow researchers, but mainly towards scientific and political institutions, and the rules a scientist has to follow to be part of them. Nonetheless she is firmly part of public scientific institutions. She works for the Italian government, for international public agencies and is the head of several European projects. Her attack against the WHO is arranged with her institution's Director and with the General Director of the Italian Veterinary

Agency. Capua thinks she «had the courage to do it, but also the freedom to do it (...) I did not end up in Guantanamo»[54] exactly because she was an (Italian) underdog: scientists belonging to important institutions are not free to break the moulds. Yet having unhinged a system, she made lots of enemies among people who work around the WHO or who belong to the political establishment, «people who say 'yes, we remember you very well, because when that thing happened it blew up in our face'».[55]

In GISAID's website, though, along with the legal procedures and arrangements, scientists are asked to adhere to the scientific good manners that Capua outright shunned. Indeed GISAID's platform «is accessible to anyone who agrees to its basic premises of upholding a scientific etiquette», resulting in collaboration, sharing and fair exploitation of the results. And as a matter of fact, the GISAID case was a positive turning point in her career. During the following years Capua will be called upon to handle important tasks through major scientific institutions such as the Center for Disease Control in Atlanta. With her increasing fame, there are even rumours that speak of her candidature as a Minister of the University and of Research in Italy. Yet Capua, confirming her antiestablishment nature, makes known that she has «tons of more important things to do» (Oriani 2006). She even turned down prestigious job offers by «top brass» while she was a guest at an interministerial conference in Sharm-el-Sheik.

Revolution in publishing

Publishing in scientific journals subject to peer review is the primary and widely accepted validation tool for scientific knowledge. A scientist's authority - and his/her career - depends on formal peer recognition. But Capua even questions the publishing mechanisms of science. She accuses colleagues of being jealous and mean, of not putting the sequences they identify into public domain «unless they have already published results in a scientific journal, in fear of not having their work recognized or of losing their rights of economic exploitation» (Pistoi 2006). First and foremost, they worry about personal success and about publishing in prestigious journals. They take advantage of the fact that avian flu «makes audience». The system that Ilaria Capua rebels against pushes scientists to practice a «sort of a publishing amongst friends, waiting for the real

[54] Interview with Ilaria Capua, January 2011
[55] Ibid.

publication, the one that will bring the researcher glory and money, as well as hope and knowledge to the hoi polloi» (Oriani 2006). Nevertheless, her ethic forces Capua towards a different choice: «what is more important? Another paper for Ilaria Capua's team or addressing a major health problem? Let's get our priorities straight» (Enserink 2006b). According to this choice, Capua gives priority to the avian flu problem over her own scientific career. She suggested that another research group had used the data she put in the public domanin in a publication, causing her group damage from the point of view of academic aknowledgment and incentives. Ilaria Capua

> has renounced the prestige of a distinguished international journal that would have given lustre to her career and has given priority to the speed of information (…) regardless of rankings (Calabrese 2006).

The role of traditional scholarly publishing in peer reviewed journals is under attack here: publishing slows down data diffusion. Furthermore, in the avian flu case publishing was driven by scientists' personal needs or by academic, governmental or institutional interests. Indeed the hacker pursues knowledge in a way that is totally independent from hierarchies and institutions. The only acknowledgment he/she looks for comes from his/her results: to crack a code is a goal in itself, and to prove that your hack works is the only thing you need to validate your work. Hackers want to write good code, not to publish peer-reviewed research papers, and they often value charismatic authority over formal and bureaucratic reward systems (O'Neil, 2009). Obviously several other biologists have criticised the peer review and scholarly publishing system and have tried to break or stress its rules. Sometimes rebels create their own independent publishing system, for example journals and other media subtracted from academic censure. In the 1960s, biologist Peter Mitchell chose to work in his own personal research institute, Glynn House, and to publish his work with Grey Books, a publishing house founded himself (Harman and Dietrich, 2008). More recently, Craig Venter forced the journal *Science* to change its policies for the publication of human genome sequencing data (Castelfranchi 2004, see Chapter 4).

Thus GISAID, Capua's answer to the canonic publishing system, proudly announces being a «truly independent database», a database «by scientists for scientists» where «researchers like you have come together».[56] This is a typical echo of hacker ethic, which imposes on programmers to produce not only their software but also the legal and technical rules and infrastructures they need to spread and manage it among peers (i.e. Kelty, 2008 for examples from outside the software field). It is also a return to a scientists' community independent from external conditioning.

Several scholars have highlighted that the publishing system for scientific journals does not satisfy all of the researchers' communication needs. In fact, they often find in popular media another important discussion arena (for a famous example see Lewenstein, 1995). Capua herself seems to corroborate this hypothesis when she urges her colleagues: «take out your sequences or get out of television news!» (Coyaud 2007) or when she engages in an intense relationship with the media, giving dozens of interviews, writing editorials and also a book directed at students willing them to begin an academic career in veterinary medicine. In a few months she becomes an international *media darling*. She also describes her inclusion within *Seed* magazine's «Revolutionary minds» or *Scientific American*'s 50 best scientists as formal recognitions at an international level: «two of the more prestigious prizes in the scientific world» (Capua 2009a), even though *Seed* and *Scientific American* are popular science magazines that do not have any scientific value according to any institutional parameter. Science institutions, with their recognition and incentive systems, are not the only world Capua lives within and gets legitimation from.

Free the data!

Capua's rebellion is directed towards the openness of avian flu data. Of course data and knowledge sharing is one of the main traits of the Mertonian scientist, one of the foundations of the mechanism and functioning of science. Furthermore, «denunciation of secrecy is ritualistic in modern science» (Bok 1982, p. 32) and it is a deterrent to inquiry into the ethical problems risen by the choice between secrecy and openness. While referring to the 17th century and the scientific revolution, William Eamon highlights the political significance of the struggles against forbidden knowledge and secrecy:

[56] www.gisaid.org

> The rejection of secrecy in science was, in part, a reaction against what was perceived to be a closed, self-contained, and hierarchical system of knowledge, and against the official policies and institutions that maintained its exclusiveness (1990, p. 356)

Sharing is also one of the most important commandments of hacker ethos. All along the facts and events that surrounded GISAID's birth, data needed to be open, accessible and free for all, unlikely the information which is kept secret or hidden by a plot, an institutional closed circle, let alone the password required to browse them. At the MIT building 26, the first generation of hackers would find any possible way to sneak into locked rooms. Doors were just another obstacle between them and free information and hackers would copy master keys in order to be able to open any door, at night, when the building was left to them.

> The master key was a magic sword to wave away evil. Evil, of course, was a locked door. Even if no tools were behind the locked doors, the locks symbolized the power of bureaucracy, a power that would eventually be used to prevent full implementation of the Hacker Ethic. Bureaucracies were always threatened by people who wanted to know how things worked. Bureaucrats knew their survival depended on keeping people in ignorance, by using artificial means - like locks - to keep people under control (Levy 2010 p. 96).

Thirty years later, Richard Stallman would fight against MIT's attempts at keeping unauthorized users out of the system. Stallman famously started a «password battle» during which he urged people to use an empty string as a password, in order to allow anybody to enter the systems and «delay the fascist advances with every method» (Levy 2010, p. 439-441). Capua spreads data and knowledge that are in her possession. Yet she also denounces and blames the machinery of secrecy that has to be broken: data is kept «under wraps» and «behind closed doors», and put into «closed drawers». «Free the data»! urges *Le Scienze*'s headline (Pistoi 2006). According to Ilaria Capua «everyone with an interest should be able to browse all the data», and as a matter of fact she «prizes openness over secrecy, access over scarcity» Anonymous 2008).

However, in Capua's discourse the reasons for action are civic, and the declared goal is the common good rather than any corporate or personal target. The currency of open science is not merely scientific reputation. In GISAID's case, one of the reasons for the WHO and some countries to oppose data diffusion is the need to prevent companies from appropriating or privatizing data which could be useful to develop vaccines or tests against avian flu. Yet in the case of Ilaria Capua, the market sat in the background, without direct links with GISAID. For example, private companies are able to develop and commercialize vaccines and drugs against the flu, as GISAID users acknowledge when they sign the database's Access Agreement.[57] Capua is not against patents per se, but rather convinced that common sense urges institutions to share crucial data which are important for public health: «they sometimes depict me as the Naomi Klein of science, but that is not true.»[58]

Openness

In the narratives about Ilaria Capua openness is indeed valuable because it can be useful to defy avian flu in a time of emergency. Information collection is a goal that always needs to be coupled with its sharing. As in the most famous hacker myths, information is something the world badly needs, and the avian flu crisis is a moment in which information can be more valuable than ever. «The current level of collection and sharing of data is inadequate, however, given the magnitude of the threat» and openness needs to be directed broadly to *all*, to humankind, «to the world as a whole» (Bogner et al. 2006). In fact, the world needs information: «our data has already been downloaded more than a thousand times», and it needs «real-time availability» of data (Cavadini 2006). Information in fact is good per se, even when it does not have any known goal, function or purpose or if the path one should follow in order to reach this goal or to fulfill its purposes is not clear. Indeed, several hackers' myths are built around the need to crack a code, to unveil hidden information just for the sake of it.

An open, accessible database? «Dream on», Capua says Anonymous 2006b). A dream that could help feed science, since there is «hunger for information (...) with my data another researcher could get to conclusions I can't even imagine» (Cavadini 2006). To hoard genetic information in a database can be a goal per se, provided it is accessible, shareable information that can be used by other scientists:

[57] GISAID EpiFlu Database access agreement, retrieved online at www.gisaid.com
[58] Interview with Ilaria Capua, January 2011

> wait a minute, we're talking about a serious potential threat to human health. (…) Not enough scientists have had the opportunity to look at this virus (Anonymous 2008).

These scientists who use GISAID must agree to «share their sequence data, to analyse the findings jointly and to publish the results collaboratively». The insistence on sharing and collaboration mirrors the license that researchers sign to get access to the database and upload or download data. Despite statements that highlight the willingness to make data accessible to «all», GISAID data are accessible to all registered users, but not to others unless they have agreed to the same terms of use. Designed after a Creative Commons license and with the help of Creative Commons consultants,[59] the database's access agreement allows scientists to «reproduce, modify, disseminate» the data and author or publish results obtained from their analysis, as long as they give credit to the originating laboratory and GISAID. Yet they can not do the same with the EpiFlu database platform and software technology, which are proprietary and partially owned by third parties as well as protected by copyright, in the nemesis of open source data licensing and users can not «copy, reverse engineer, disseminate or disclose» any part.[60] Openness does not apply to every layer of the information environment: the content layer is open while the logical level, composed by standards and software, is subject to copyright (Benkler, 2006).

Mobilising ethic

In this chapter I analysed the story of Ilaria Capua during the avian flu crisis from 2006 to 2009. During this period, her refusal of the WHO publishing policies and her role in the birth of GISAID, the open access database for the sharing of avian flu virus data, have brought her fame, prizes and a reputation as an international open access advocate. She also built an important alliance of scientists, policymakers, public institutions, foundations, and private companies. Furthermore, different scientific communities backed her efforts, most significantly veterinarians, epidemiologists and geneticists who joined her in this battle. I examined the question as to whether Ilaria Capua should be considered *just another rebel scientist*, namely if and how her story could simply be

[59] http://creativecommons.org/about/licenses
[60] GISAID EpiFlu Database access agreement

assimilated with that of the traditional public image of the scientist as a pathbreaker and rebel against hierarchies of established knowledge. My goal was then to understand the characteristics of Capua's public ethic that emerged in the media coverage related to the birth of GISAID. In order to do that in the empirical analysis I conducted, I referred not only to Mertonian ethos but I also used the hacker ethic as an analytical tool. Capua's public ethic represents a reconfiguration of these two ethical systems. My argument is that this cultural remix represents more than the re-emergence of an ancient and recurrent character in the history of science.

Not just another rebel scientist

I suggest, thus, that Ilaria Capua is a good example of a remix between an old accepted culture embodied in a complete set of practices and norms and a more recent culture that we can see at work in several other fields of innovation. In this sense, public ethic is one of the possible cultural characteristics that individuals can mobilize when the need for a reconfiguration of different aspects belonging to one or more pre-existing cultures become more insistent. And this happens mainly in contexts of crisis and change such as the ones Capua went through. Indeed, as I argued in Chapter 1, cultural frameworks can both enable and constrain individual processes, providing actors with flexible yet resistant tool kits. Contemporary scientists can still find cultural elements in Mertonian science ethic that fit with their needs for the production of a successful public image because the influence of that culture still remains, even though the social dimension from which it was born does not exist anymore. But they often need to be remixed with new and different ethical and cultural elements. Again, with regards to her role in the birth of GISAID, the individual elements of Capua's public image are not innovative, and yet the remix is innovative, this recombination that I have described. Ilaria Capua belongs to a longstanding tradition of scientists rebelling against established ideas and the upper echelon amongst their colleagues (i.e. see Harman and Dietrich, 2008 or Dyson, 2006). But she is not *only* another rebel scientist. Instead, she embodies a new and emerging figure of the scientist, one who uses some open source and open access tools more attuned to the current configuration of science and society relations. Yet at the same time she is not *only* an open access advocate. The call for the adherence to open science does not apply to every layer of the information environment she lives within, and it is always coupled with her rebellion against bureaucracy and her claims of independence from both academic and corporate institutions. In the narratives that depict her role in the birth of GISAID, several classic features recur, such as autonomy, independence and openness. But along with these, other characteristics emerge: the radical refusal of external interference and also of scientific institutions themselves; a component of hedonism; the insistence on bare information as a good per se, as long as it is shared and accessible; the importance of being an underdog; an intense relationship with the media.

Thus, the hacker Ilaria Capua attempts at shaping scientific institutions, pushing them towards a transformation in the direction of a more open environment for the exchange of information, one in which the power of Big Bio bureaucracies is diminished in favor of a more horizontal model. The WHO has been, in a sense, one of the last international institutions to resist to the spreading of expressly open access policies. Finally, Capua rebels against mechanisms of publishing and peer review of scientific knowledge in the name of a type of cooperation that is directly enacted between scientists and not mediated by institutions. Her attempts to legitimize herself outside of some of the major institutions of science cause her to break their mechanisms. Her main interlocutors seemed to be the scientific community formed by peers and the media.

Hacking the rules of the game

With her insistence on openness, rebellion and antiestablishment critique, and ultimately her role in restoring a lost ethos of science, Capua is once again making «moral» the public image of a scientific field that badly needed a renewal after the anticommons crisis and the legal, political and societal clashes that came with it. Indeed, public communication is an important tool scientists need to use in order to overcome social backlashes and to thrive in a demanding social environment (Bucchi, 1998, Greco, 2002). The results she obtained in terms of shifts in institutional policies, institutional appointments and media prestige make one think of a peculiar ability to mobilise public ethic as a means for positioning within current transformations in science. However, besides her personal results, Capua's case can be intepreted as a symptom of the emergence in biology and genomics of a new open science culture. The case of Ilaria Capua is particular - she is a scientist who works for public agencies and she is not strictly linked to private corporations. But in the world of genomics, biological innovation takes place in increasingly more complex and mixed configurations, in which open data policies and open access coexist with different, and more strict sets of intellectual property rights or secrecy (Benkler, 2006, Hope, 2008). Also the corporate world has increasingly been using diverse and mixed approaches to intellectual property, and in some cases - such as database management - strictly proprietary models are seen as no longer sustainable. In GISAID itself, content is distributed through an open access license while the database software platform is protected by copyright.

Ilaria Capua is hacking biology and its rules because she is actively participating in the transformation and shaping of the current platforms for genetic data sharing, as well as the institutional configuration that sustains it. She is neither merely another rebel scientist or a prominent member of the movement for open access in scholarly publishing. Capua rather represents an attack against one of the last closed public institutions. An attack made of course in the name of openness and sharing, but also in the name of the need to subtract power from the slow, non-transparent and corrupted priesthood which runs Big Bio in the public sector.

* 6

We are the biohackers. DIYbio and the rise of garage biology

> *DO IT!*
>
> *Jerry Rubin, 1970*

Some people actually call themselves *biohackers* and refer explicitly to the hacker movement and history. DIYbio (Do-it-yourself Biology)[61] is a network organisation of amateur biologists established in Boston in 2008 and composed of several groups in major US and European cities. Their aim is to provide non-expert, citizen biologists with a collective environment and cheap and open source tools and protocols for biological research which can be conducted in amateur settings. This so-called «garage» biology is conducted in weird places such as garages or kitchens. During the last two years DIYbio has become an important movement that is spreading all over the world. It has also attracted the attention of the media, who have intensely covered the birth and the evolution of DIYbio and other related citizen biology projects. In one sense, garage biology is part of a well-known story: the emergence of online platforms for the open and collaborative production and sharing of information and knowledge (Benkler 2006). Within this general framework, in the last few years we have witnessed the emergence of science movements that rely on the Internet in order to share data and information and to organize offline groups that are geographically dispersed (see Chapter 2). In a sense, these movements represent today's expression of an old phenomenon. According to Clifford Conner (2005), the free software movement is the latest expression of the *People's History of Science*, a long history of the participation of carpenters, mechanics, miners and outsiders in knowledge production. It is not difficult to imagine one could include citizen biology in this narrative. On the other hand though, citizen biology represents an unheard of challenge to Big Bio. As I will show in this chapter, these experiences represent an open and collaborative science not limited to the expert community, but rather one that opens and crosses the frontiers of expertise and scientific institutions. In fact, the diffusion of collaborative web

[61] www.diybio.org

tools and deeper transformations in the way science is conducted have given people new tools that allow a proactive approach to information production and to the shaping of the techno-scientific environment in which they live. This makes DIYbio a very interesting example of a direct translation of free software and hacking practices into the realm of cells, genes and labs.

Thus, in this chapter, my reference to the hackers does not need to be metaphorical, as these amateur biologists love to be called biohackers. Besides their very diverse sets of ethical characteristics, the members of DIYbio also have straightforward relationships with the hacker movement. For example, their models are hackerspaces, collectively run spaces that are now widespread in Western countries and where people gather to hack, talk about and work on computers; spaces where subscribers for a low individual monthly rate can find computers, tools, and other people interested in hacking. Sometimes, when they can not open their own labs, DIYbio groups collaborate directly with existing hackerspaces in order to set up small labs, or «wet corners» within the computer hardware that fills urban hackerspaces. DIYbio members and groups are also immersed in a dense entrepreneurial environment where start-ups and new open science companies try to navigate their way through the dominance of the Big Bio market.

I am aware that what we have witnessed represents nothing but a preliminary phase in the development of a possible broader and stronger movement. Yet although so far no important scientific innovation has come from citizen biology, the novelties that characterize citizen biology have been described in terms of open and peer knowledge production, danger to public health, co-optation, democratic (or apocalyptic) change in the relationship between experts and non-experts, ethical dilemma and public engagement with science (see for example Bloom 2009, Kelty 2010, Ledford 2010, Schmidt 2008). Yet in this chapter the main perspective I adopt is different: I draw a comparison between garage biology and the history and culture of hacking and free software and the way to represent an updating of the Mertonian ethic. I also briefly analyse the entrepreneurial practices, the relationship with institutions and the approach to intellectual property that characterize this movement. This allows me to rethink the meaning of DIYbio ideas of participation in science and to suggest this movement is an actor in the shaping of the current innovation regimes in the life sciences as well as plays a role in the relationship between research, academia and the market.

My study is based on four months of participant observation both online, in DIYbio mailing lists, and offline within local groups and hackerspaces on the US West Coast, in particular in Los Angeles (SoCal DIYbio) and Seattle. I also conducted interviews with several prominent members and analysed two years worth of communicative materials from multiple sources such as press articles, interviews, scientific papers and groups' websites.

DIYbio.org

An early explicit reference to the possibility of enacting a biohacker way of conducting life sciences research traces back to 2005, when Rob Carlson, a physicist who works in the field of genetics, wrote in a *Wired* article that «the era of garage biology is upon us» (2005). Carlson was working at a Berkeley lab and got inspired by the history of the computer revolution that had happened 30 years before in San Francisco Bay Area garages (Golob 2007, Ledford 2010). Three years later, exactly in the other epicenter of hacking history, DIYbio was born. In fact, the movement started in Boston in 2008 stemming from an idea by Mackenzie Cowell, a young web developer, soon joined by Jason Bobe, the director of community outreach for the Personal Genome Project at Harvard Medical School. At the first public meeting, held in a pub in Cambridge, Massachusetts, 25 people turned up. But in 2010 about 2,000 people had subscribed on the DIYbio mailing lists. Most of these 2,000 are interested in citizen biology but not active. Yet at the end of 2010 DIYbio counted dozens of local groups, with new chapters popping up in places as far from Massachusetts as Madrid, London and Bangalore. In the US the biggest groups are based in the San Francisco Bay Area, New York, Seattle, Los Angeles, Chicago. DIYbio is not a formal organisation but rather an open brand anyone can use for citizen science projects, coupled with a global mailing list where most discussions are conducted and decisions taken. In collaboration with or partially overlapping DIYbio, several other citizen biology projects have emerged and form a complex network of different experiences. Still, some more visible members somehow have the ability to direct this brand and are thus identified with DIYbio.

I want to highlight that today no active garage laboratories exist, and that in many cases garage biology consists of very elementary scientific practices, such as DNA extraction or bacteria isolation with household tools and products (you basically need a kitchen centrifuge, dish soap and a few other easily available chemicals to create a buffer solution and extract DNA from strawberries). In most cases, the media attention overstates and mythologizes very poor scientific practices: right now garage biology is not a site of research and innovation. But during the last two years DIYbio groups have started several scientific projects. Interesting projects have focused on building open source lab hardware. The Pearl Gel System is a cheap and open source gel box that can be used to run electrophoresis.[62] One garage biologist has created a centrifuge that works with a cheap and very diffused power tool gadget. The design for the centrifuge can be downloaded for free and fabricated with a 3D printer (Ward 2010). In the BioWeatherMap project, people are asked to collect bacterial samples from crosswalk buttons in their cities in order to analyse the geographic and temporal distribution patterns of microbial life in a highly distributed way.[63] SoCal DIYbio is planning to use Amazon cheap cloud computational power and JCVI Cloud Biolinux software[64] in order to conduct grassroots bioinformatics and data analysis. In New York, DIY biologists are extracting and genotyping people's DNA in public events.

In the past two years DIYbio has also established dialogues and relationships with universities, private companies, media and the US government. DIYbio has raised concerns of security and safety among biologists, ethicists and government agencies (Schmidt 2008). This is why the movement has an intense relationship with the Federal Bureau of Investigation (FBI) and with the Presidential Commission on Bioethics. After the problems faced in the US by people who performed garage biology during the years of the post-9/11 and anthrax histeria, both the government and DIYbio want to prevent possible problems, misunderstandings or surprises. In fact, one of the images the press use to talk about biohacking is that of biosecurity and even bioterrorism: are crazy kids playing with dangerous bugs that some terrorist might use to spread unknown diseases and panic (Schmidt 2008)? Indeed, «Hacking is good. But you have to admit the word has a bad reputation,» as a *Nature Biotechnology* article argued (Alper 2009, p. 1077). Furthermore, DIYbio has appeared in dozens of media reports in newspapers and magazines such as *The Guardian*, *BBC*, *The New*

[62] www.pearlbiotech.com
[63] http://bioweathermap.org
[64] http://cloudbiolinux.com

York Times, *The Boston Globe*, *The Economist*, *Wired*, and the like. Also several mainstream scientific journals have covered the DIYbio rise, for example, *Nature* and *EMBO Reports* (Alper 2009, Ledford 2010, Nair 2009, Wolinsky 2009).

Through their website and several local online spaces the members of DIYbio organize collaborative research projects and share scientific data and information. The people who compose DIYbio are very diverse, and they basically belong to three different groups: young biologists, such as graduate or even undergraduate students; computer scientists and geeks who want to tinker with biology; bioartists interested in applying the critical approach of DIY to biology. Some members are concerned with the fact that no real garage labs are in place and that access to biological tools and lab equipment is hard to get, expensive and strictly regulated, so that a real garage biology movement is far from appearing. Yet in 2010 DIYbio and other citizen biology projects opened several community spaces, such as Sprout in Massachusetts and GenSpace in New York[65] and launched Biocurious, a biohacker space to be opened in the Silicon Valley.[66]

Hackers, rebels and citizens

DIYbio is often referred to as a biohacker community, and its members very freely use that type of definition. The answer to the question, «Who is a 'biohacker'» in DIYbio FAQs include hacking as a subculture, the combination of the hacker ethic of «biologists, programmers, DIY enthusiasts,» explicit references to the Homebrew Computer Club and the Free Software movement, the importance of enjoying «hacks» and finally the «biopunk» attitude.[67] One of the big public events that presented DIYbio to the world was the hacker conference CodeCon, that in 2009 replaced one third of its normal program with a special focus on biohacking.[68] The media narratives on DIYbio use the definition *biohackers* almost ubiquitously, together with similar definitions such as, for example, *life hackers* (Ledford 2010), and they often draw comparisons between garage biology and the Homebrew Computer Club, the headquarters of Seventies Bay Area computer hackers such as Steve Wozniak, Bill Gates, Steve Jobs and so on (Bloom 2009, Economist 2009, Golob 2007, Johnson 2008). Yet

[65] http://genspace.org
[66] www.biocurious.org
[67] http://openwetware.org/wiki/DIYbio/FAQ
[68] http://www.codecon.org/2009/program.html

some individuals linked to DIYbio prefer to define themselves as makers, craftsmen, enthusiasts, hobbyist or amateurs. They often agree, though, that the garage is an important part of the love the media express for DIYbio. Garage labs are places where one can develop his/her curiosity, creativity, desire to tinker with genes and cells. After all, hackers that performed the computer revolution were nothing but «a bunch of unshaved guys in a garage» (Golob 2007). Press accounts of DIYbio and the members I interviewed highlight how garage biology is to be considered part of the tradition of American innovation – think about Apple or Google and the mythology related to the Silicon Valley garages where they started operating (Levy 2010, Vise and Malseed 2006). After all – who knows? - «the future Bill Gates of biotech could be developing a cure for cancer in the garage» (Wohlsen 2008).

Other similarities between DIY biology and hacking are in the obstacles biohackers identify in Big Bio. As I will show below, in DIYbio narrations universities and corporations are flawed because they rely on high specialization and hierarchical systems, but also because they build monopolies and steal individual creativity by means of intellectual property rights. Big Bio hulking giants are neither open nor inclusive. Perhaps, as Jason Bobe said, «there will always be the giant players – the biotech and pharmaceutical companies – in life sciences» (Nair 2009, p. 230) but the widespread diffusion of information and sequencing technologies will allow amateur biologists to contribute to the scientific enterprise.

Of course, fun and hedonism are also important ingredients of DIYbio culture. As the DIYbio founder Mac Cowell said, DIYbio «gives people the justification for doing silly or weird things» because, as in many narrations on rebel science and on hacking, «innovation arises from having fun and playing with biology».[69] Cowell quit his job because «he wasn't having fun anymore» and sold his car to start DIYbio (Boustead 2008). Exactly as Woz sold his Volkswagen van to start Apple in his garage (Levy 2010). Of course hackers do not always like the sunlight. On the ninth floor of building 26 at MIT, hackers would work all night in order to avoid the priesthood which wasted precious time using university computers for dumb tasks, but also because of their weird circadian rhythms and lifestyle. And so do biohackers: «you'll be tweaking genome

[69] Interview with Jason Bobe, July 2010

sequences on your computer late at night» (Carlson 2005). You won't be able to stop the passion of hacking.

DIYbio discourse is also laden with informational metaphors: the standardisation, abstraction and digitalisation of genetics will give more people the opportunity to do biology (on this see Keller 2000, Haraway 1991, Kay 2000). The DIY side of garage biology is also related to a turn in life sciences towards more active and interventionist practices, recently enacted by the rise of synthetic biology and its accent on *making* organisms rather than modifying them (Keller 2009). Yet the use of software metaphors is not limited to genes. When dealing with the FBI, biohackers want to highlight how and why they want more transparency: «it is like software... it is security through transparency.»

References to hacking are dominant. But the use of the term «Do-it-yourself» positions DIYbio within an old American movement of makers and inventors who work in their garages and also gives it a rebel flavor. The expression DIY was broadly adopted in the Eighties by the punk-hardcore movement both in America and Europe. Yet this movement is witnessing a renewal and is now part of a broader social phenomenon centered around the convergence between online peer production, the diffusion of cheap and open source tools and machinery (such as 3D printers) and a widespread «maker» culture (Niessen 2011). DIYbio is part of this movement, which main communication tools are magazines such as *Make*[70] or websites such as *Instructables.*[71] This is also a link between biohacking and craftsmanship. Christopher Kelty, one of the very few scholars who has started addressing garage biology from the point of view of its sociological and anthropological dimensions, argues that three figures can be used to understand citizen biology, namely outlaw, hackers and Victorian scientists (Kelty 2010). DIYbio, in some media accounts, is «a throwback to the times when key discoveries were made by solitary scientists toiling away in their basement labs» (Nair 2009, p. 230). Also, one of the founders of DIYbio, Jason Bobe, draws this comparison: «in some sense, we're returning to some of the roots of biology, where scientists had laboratories in their parlors. You know, it was parlor science. It was something that didn't actually happen often in institutional settings; it was something that happened at home» (NPR 2009). For Drew Endy, a Stanford

[70] http://makezine.com
[71] www.instructables.com

bioengineering professor who is one of the strongest backers of the garage biology movement, «Darwin may have been the original do-it-yourself biologist, as he didn't originally work for any institution» (cited in Guthrie 2009).

Active citizenship

Thus, for its members, DIYbio is not only biohacking but many other things as well. It is public engagement with science, open source, decentralisation, participation, innovation. When asked to interact with the FBI or with the US Presidential Commission for the Study of Bioethical Issues,[72] DIYbio proved very capable of finding ways to position itself in order to avoid backlash and problems. For example, they decided to highlight that citizen biology has an educational side, and that it could provide cheap hardware or kits to be used in schools or community labs, besides giving people a vibrant online community to discuss about science. DIYbio might become a «cultural interface» for biology, a place for people to explore biotech. In their letter to the Presidential Commission, members argued that

> DIYbio.org was created to help build a positive public culture around new biotechnologies and practices as the number of contributors to the life sciences extends beyond traditional academic and corporate institutions (DIYbio 2010)

There is a classical problem of the relationship between science and society at stake: participation. It is easy to state that P2P practices are changing and increasing the ways of participating in the production of scientific knowledge. But does this increase consist of a real shift towards democratizing science? Does it actually affect the asymmetrical relationships between citizens and experts? Scholars who have tackled this relationship have generally been very prudent in picturing participation in science. Often, ambivalence is highlighted. Callon and Rabeharisoa (2003) point out that «research in the wild,» or the intervention of patients in biomedical research, involves their active participation in establishing new collectives that include new subjects. Also, the renegotiation of the relationship between research in the wild and research conducted in professional settings involves issues of power, epistemology, and the presence of incentives of a new and different nature. The changing panorama of expertise urges lay people

[72] www.bioethics.gov

to get actively involved in techno-scientific decisions in order to change the world and not just observe it (Collins and Evans 2007). While referring to geeks and the diffusion of free software practices outside the computer world, Kelty (2008, 2010) argues that the public can be not passive, but instead «aggressively active». Do-it-yourself science certainly challenges mainstream science, asking for more access and involvement. But amateurs are also redefining what being «the public» means in the current configuration of science/society interaction: an active role substitutes the simple encounter between science and its public and creates new spaces of interaction and participation (see Nowotny 1993). DIYbio is a site where different approaches coexist. For example, through DIYbio amateurs who work outside of traditional professional settings can have «access to a community of experts.»[73]

This is not too different from the perspective of Critical Art Ensemble (CAE), an art/activist group whose works and writings are considered by many garage biologists as a foundational myth.[74] In 2004, one of the CAE members, Steve Kurtz, was arrested under the suspicion of bioterrorism when, after his wife died of a heart attack, the FBI found cell cultures and lab equipment in his apartment (Simmons 2007). CAE used amateur biology as a tactical practice in an artistic context in order to create what they called «a countersymbolic order» against the power of Big Bio. The public space their practices aimed at creating was intended to be

> one where the authority of the scientific personality is not so powerful. The hierarchy of expert over amateur has to be suspended in this context. If experts have no respect for the position of amateurs, why would they come to a place where dialogue is possible? (Critical Art Ensemble 2002, p. 66)

Yet the vision of citizen biology as a site for participation has a completely different side. While for CAE, the goal was to enable people to challenge the capitalist face of Big Bio by providing conceptual and political tools, in some biohackers' view, participation could help overcome some of the problems faced by Big Bio itself. In fact, biologists are gathering more and more genetic data without exactly knowing what to do with them. But for garage biologists

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[73] http://openwetware.org/wiki/DIYbio/FAQ
[74] www.critical-art.net

> genomes are useful right now. They can be useful if people share their phenotype, and that is something the citizen himself has, not the expert. The future of human genomics will depend on individuals sharing.

There is an ambivalence, though, with respect to the political and economic role of this sharing: is it going to be part of an expropriated gift economy (Levina 2010 and Terranova 2000, see Chapter 2) or rather a resistance against intellectual property rights enclosures that sustain Big Bio monopoly power? The biocitizenship imagined by DIYbio includes very different features, as I will show in the following paragraphs, and the answer to the question is not clear among garage biologists.

Free as in free genes

When it comes to openness and sharing, DIYbio members would certainly agree with the free software foundational definition: «free as in free speech, not as in free beer.» Access to knowledge is another important framework under which DIYbio operates, as it enables citizen participation in science. Indeed, openness is one of the core legal implications and needs of user-led science. In «Open science: policy implications for the evolving phenomenon of user-led scientific innovation,» Victoria Stodden (2010a) analyses citizen science in relation to the access and sharing of knowledge. Public involvement and collaborative models between scientists and non-scientists need policy solutions that support not only data and knowledge sharing, but also the sharing of benefits deriving from it. Drawing from computational science examples, Stodden points out that the incentive model of citizen science is closer to that of open source software than to that of Big Bio. But for DIYbio, openness refers both to the open access to data and knowledge according to an explicit open source model, and to open participation directed to *all*, regardless of professional recognition from Big Bio. As DIYbio wrote in its online FAQ page, the organisation is a «groundwork for making this field open to anyone with the drive to become great at it.»[75] In which sense, then, the free software model would apply to genes and cells?

[75] http://openwetware.org/wiki/DIYbio/FAQ

How to build a PCR

In typical hacker fashion, garage biologists have different modes for finding the tools and machinery needed for their labs. These tools are usually very expensive or difficult to buy since companies do not often sell equipment, reagents and so on to individuals for safety and regulatory reasons (Alper 2009, confirmed by several interviews) but also because, as one garage biologist says, «they do not perceive the possibility of a non-institutional market.». This constitutes a threshold that is hard to overcome. The story of two PCR machines can explain how DIYbio answers this problem. In San Francisco, two young electrical engineers, Tito Jankowski and Josh Perfetto, are developing OpenPCR, a project to build a cheap Polymerase Chain Reaction machine under open source principles: anybody would be free to download the instructions to build it and the software to run it, and then have an easy to use, $400 machine at their disposal. As for other DIYbio projects, the money needed to develop OpenPCR has been raised with a crowdfunding scheme through the website Kickstarter.[76] Yet in Los Angeles, SoCal DIYbio have found two used – and broken – PCR machines that the group fixed using members' electrotechnical skills and adapting free software to make it control them. Other DIYbio techniques for putting together cheap equipment include stealing, buying used stuff such as benches or glassware from university labs, or using the university address of their graduate student members in order to get material shipped from companies. They also use skills some of them acquired working in «ghetto labs» in universities that were not well-funded. As a garage biologist said, «we don't care where the shit comes from. We want shit that works!». Before receiving a PhD in an important US university, a DIYbio member had worked as an undergraduate in a small lab, where she

> learned some skills on how to run a lab without spending any money: how to get free equipment from companies asking for sample... I have a ghetto sense now. But still, we published papers out of that lab.

Again, apart from the problem of intellectual property, garage biologists have an ambivalent relationship with big institutions. On the one hand, they heavily rely on universities for material, education, used machinery, and other needs. Yet

[76] http://openpcr.org

they also have problems with being recognized as having real scientific projects. In 2009, for example, DIYbio was excluded from the annual iGem competition, where dozens of teams of undergraduate students from all over the world compete to design and build the best biological systems and operate them in living cells.[77]

The Bayh-Dole Act Sucks!

An interesting feature of DIYbio values is that often intellectual property rights are not perceived as evil per se. It surely adopts a very open attitude, using open access tools, Creative Commons licenses and so on when it comes to sharing data, protocols of knowledge. Yet the ambivalence that characterises DIYbio emerges when, talking to different members, one finds out that for some, of course, there is a political commitment to open science: to prevent people from making science is against freedom of thought. But for others, openness is a means towards a different end: entrepreneurship. Like for the passage from free software to open source (see Chapter 2), openness is a way of defying incumbents and restoring the freedom of the market. «If only I could have put all the money I paid the damn lawyers into the molecules!» states Rob Carlson,[78] a biohacker whose main problem is to get over the obstacles represented by the broad patents owned by Big Bio: a typical anticommons effect (Heller and Eisenberg 1998, see Chapter 1). Thus, often when DIY biologists talk about innovation happening outside traditional settings such as academy and corporations, they also want to highlight that openness is not only good per se but rather part of the strategies against Big Bio monopoly power.

Indeed, biohacking is laden with anti-institution and anti-bureaucracy claims. Giving people cheap and widespread tools for biology, some DIYbioers want to «make people less reliant on other people for living a good life». They also want to avoid academic paternalism and demystify «official» science. For example, even though many members are getting their PhD, the importance of the normal, institutional course of scientific education is not taken for granted. One important barrier of entry for people who want to practice biology is formal education: a PhD title «is overglorified and I want to show it» said a graduate student convinced that participation in DIYbio projects was more important than

[77] http://ung.igem.org/Main_Page, see Alper 2009

[78] Interview with Rob Carlson, August 2010

a formal, «normal» university career, something biohackers want to demystify (Wolinsky 2009). According to Jason Bobe, one of the DIYbio founders, we are going to see a scientific renaissance that will be funded and enacted outside the ingumbrant incumbents of Big Bio and their slow and bureaucratic processes. The peculiar feature of this renaissance is that «it's going to take place outside of 'science proper', away from universities which dominate now, and funded out-of-pocket by enthusiasts without PhDs» (2008). In sum, «we're all doctors here, man!» as another DIY biologist said during a meeting. Moreover, formal education is an aspect of Big Bio that garage biologists cannot stand because it is the expression of the power of an old boy network that must be broken:

> nowadays, biology is like a medieval guild. Firstly, you have to get a PhD, but if you want to practice then you need venture capital, otherwise you don't have the tools (Bloom 2009)

According to Eri Gentry, one of the founders of Biocurious, people «want a space where they can work on their own projects, outside institutions they hate, such as universities and corporations.»[79] Tito Jankowski is even more enraged: «the Bayh-Dole Act sucks! People don't want to give their ideas and their intellectual property to their institutions.»[80] Patents are not only a moral problem or an obstacle to innovation. The Bayh-Dole Act urges researchers working in public institutions to patent their findings and inventions through the university (see Chapter 2). But for some DIY biologists, this is a problem related to individual rights rather than a more general problem of knowledge privatisation and academic capitalism. They want to keep their intellectual property rights and not to remise them to big institutions they work for in their daily jobs.

The Homebrew Molecular Biology Club

Thus, DIYbio embodies very different faces of hacking such as openness in data and knowledge sharing as well as openness of the doors of scientific institutions, but also rebellion, hedonism, passion, communitarian spirit, individualism and entrepreneurial drive, distrust for bureaucracies. DIYbio is a really interesting case because it includes all the cultural and political ambivalence of hacker ethic and FLOSS practices (Barbrook and Cameron 1996, Coleman 2004, Coleman and

[79] Interview with Eri Gentry, October 2010
[80] Interview with Tito Jankwski, October 2010

Golub 2008). In its case, rather than highlighting a peculiar recombination, it is more correct to talk about the coexistence of several cultural traits taken from different ethical sets, such as the Mertonian ethic, the hacker and free software cultures, and older cultures such as the gentleman scientist's one.

For now, the results of DIYbio have been very modest. So, from the scientific viewpoint it is hard to state that they are actually hacking DNA and cells, and we do not know if they will be able to hack them in the near future. Yet DIYbio is making biology hackable in several ways. First, the kind of acknowledgment and incentives they recognize are not always related to the ones of institutional science: a good hack does not need to be peer-reviewed, though it surely has to be shared with other biohackers. You do not need a PhD to do biology. Second, garage biologists use informational metaphors and aim at standardizing genetics in order to make it cheaper and more easily accessible. Third, they are opening community spaces for people to conduct biology outside the boundaries and limits of Big Bio. Finally, they are trying to open up the boundaries of life sciences entrepreneurship by experimenting with new business models based on open source approaches.

I think that one of the reasons of DIYbio's incredible mediatic and political success, regardless of poor scientific output, is due to its symbolic power. DIYbio, making biology hackable in all these different ways, is producing the picture of a different way of conducting research in the life sciences: more open, horizontal, within a very mixed constellation of different actors such as start-ups, universities, individuals, community spaces, with a prominence of small and open companies instead of Big Bio slow giants. They are also a powerful antidote against the critiques that have hit biology during the last 20 years, after the wave of privatisation, patenting and the transformation of institutional settings in which life sciences are conducted. Thus Big Bio will perhaps have to take into account their needs and interests. Companies and scientific institutions are asking citizens to contribute by crowd-sourcing knowledge, sharing and analysing data, or performing scientific research (Delfanti 2010b, Hope 2008, Levina 2010). Will they be able to open themselves up to a more inclusive relation with citizen science? Well, if they won't, they might have to face rebellion, at least according to some biohackers. In her *Biopunk Manifesto* the hacker and DIY biologist Meredith Patterson pompously (and ironically) states:

> We the biopunks are dedicated to putting the tools of scientific investigation into the hands of anyone who wants them. We are building an infrastructure of methodology, of communication, of automation, and of publicly available knowledge. (…) We reject the popular perception that science is only done in million-dollar university, government, or corporate labs; we assert that the right of freedom of inquiry, to do research and pursue understanding under one's own direction, is as fundamental a right as that of free speech or freedom of religion. (…) The biopunks are actively engaged in making the world a place that everyone can understand. Come, let us research together (Patterson 2010).

With its radical requests for openness and inclusion and with its rejection for institutional prerogatives and constraints, garage biology surely challenges many assumptions about public participation in scientific knowledge production. Citizen scientists and users contributing to science claim to be part of the scientific process on almost any level. They point to a problem in the current distribution of power over knowledge. Distributed social production has already proven to be enormously productive in many fields of human knowledge and DIYbio claims for a positive change accompanied by a redistribution of that power. Yet for some garage biologists, the relationship with institutions and Big Bio cannot be one of a punk refusal, a menace against the established order. For Jason Bobe, DIYbio needs to be transparent, friendly, open to dialogue: «we want to encourage people not to be punk, underground biohackers.»

Steal this genome!

Thus garage scientists depend on big science but try to live beyond its frontiers, in no man's land: they are somehow *outlaws* (Kelty 2010). This has important implications for the relationship between different types of expertise, as I argued above. But here I also want to draw a comparison between garage biology and other forms of production situated outside the boundaries of institutions. In *Convergence Culture*, Henry Jenkins (2008) depicted the clashes that involve fans and mainstream media industries. Fan creation «in the wild,» as I would say to connect Jenkins with studies on the participation of lay people in biomedical research, can be a very rich field companies can harness to capitalize new content and get in touch with their public (Arvidsson 2008, Terranova 2000). On the other hand, companies are always challenged by content creation that happens outside their boundaries because they need to control it in order to avoid injury, and this can be a very expensive and puzzling task. The pessimistic side of this balance is represented by exploitation of people's creativity and appropriation of free labor by greedy corporations (see Chapter 2). This description somehow echoes Marx's ideas of the relationship between capital and labor. Italian autonomist Marxists have, since the late Fifties, argued that workers' struggles are one of the main engines of technological innovation and of capitalism transformation and evolution. Yet capital is never able to fully control workers' social practices, or to reconciliate its inside and its outside. This very edge is where capital struggles to survive, feeds with new ideas and solutions, and therefore evolves. Struggles against exploitation are both the driving force and the opposition of capital (Hardt and Negri 2000, Marx 1990, Panzieri 1976).

Of course, garage biologists are neither workers struggling against capital, nor fans shooting a short movie of the Star Wars saga without the authorisation of George Lucas, but they have an ambivalent role with respect to Big Bio. One interesting question is whether in the future their hacks will favour, change or disrupt today's life sciences incumbents. They challenge in new and deeper ways the separation between the roles of experts and non-experts. They refuse the absolute authority of universities on scientific recognition (we're all doctors here!) and of both academia and industry on intellectual property rights (the damn lawyers! The Bayh-Dole Act sucks!). But they also represent an attempt at participating in new ways in an innovation regime that includes universities, corporations, start-ups, patients associations and so on. Many members of DIYbio refer to, for example, the possibility of developing a new market for biology tinkering tools or for small companies not dependent on patents but based instead on open science practices. «We gotta find a way of marketing this!»

Less than ten years ago, CAE was highly skeptical about the possibility of a corporate side of amateur biology when it argued that «even entrepreneurs do not seem to have any interest in finding a way to capitalize on this divide» between experts and amateurs (CAE 2002, p. 123). Yet an important part of DIYbio invests exactly in the role of entrepreneurship and corporations in sustaining a possible biohackers movement. In this sense, again, DIYbio's relationship with Big Bio is ambivalent. The anti-bureaucracy side of garage biology is trying to challenge Big Bio incumbents. Garage biologists would like to dismantle monopolies based on intellectual property rights, capital-intensive laboratories and scientific expertise. Yet most of them are not interested in a critique of academic capitalism or biocapitalism, but rather in the possibility of opening up new markets where smart, small scale and open source models could compete with Big Bio and its Hulking Giants. Others hope Big Bio would finance their activities, recognizing biohackerspaces and biohacker communities as innovation incubators where new ideas, start-ups and entrepreneurs might come from in the near future. Both models are similar to the free and open source software economic models. On one hand, a smart challenge to big, closed corporations enacted by small and peer production projects that can count on openness to harness people's cooperation and find faster and better solutions. On the other hand, a direct participation of big corporations in open production.

* 7

Conclusions: how to hack a genome

There's a place for you in the New Information Order
Processed World, 1984

The cultural elements evoked by these biologists are not completely innovative, yet what is innovative is the recombination of these elements. To understand the characteristics of the public ethics that emerged in the media production related to these cases and in the self-representation of their protagonists, I referred not only to Mertonian ethos but I also used the hacker ethic as an analytical tool. In fact, I argue that their ethic represents a reconfiguration of these two ethical systems. They are not *only* rebel and independent scientists, and at the same time they are not *only* open access and open source advocates. My proposal is to consider this remix between the Mertonian ethic of 20th century scientists and the ethic of hackers as a new form of open science culture that not only embodies elements related to openness and sharing, but is rather a more complex recombination in which alongside these, other characteristics emerge: antibureaucratic rebellion, extreme informational metaphors, institutional critique, autonomy, independence, a radical refusal of external interferences and also of scientific institutions themselves, hedonism, the importance of being an underdog, and finally an intense relationship with the media. This culture expresses the re-emergence of an ancient and recurrent element in the history of science, namely the fight between openness and closure. But the complex and diverse cultural repertoire of biologists included in this study is pretty different from the classical ethic of modern scientists who work in academia, are disinterested, respectful of bureaucracy and peers, not compromised by the market. At the same time, it is also different from a corporate ethos of secrecy, hierarchy, closure. In any case, I do not think they represent a break in the norms regulating the production of scientific knowledge. These biologists are rather expressions of the transformations affecting the relationship between biosciences, society, public communication, and the market. They also embody a change in the media landscape. The media have a crucial role in making some scientists «visible» and giving them an important public dimension. But the rise of new media also represents the technological foundations of transformations in the way knowledge is produced, shared, discussed and legitimated.

Biohackers

Actually, hacking DNA means several different things. The cases I presented here share an open approach to information, but this is not enough. These cases illustrate a tension between scientists' cultures and the transformations of postgenomic biological research. They surely show the different possibilities enabled by open science practices. But also features such as rebellion, anti-bureaucracy and participation have a crucial role in making DNA something people can hack. All these biohackers criticize the scholarly publication and peer review system. They all struggle against Big Bio bureaucracies and incumbents. Yet there are differences and peculiarities that are useful to highlight the contingent and very diverse typologies of hacking they represent. In fact, they consistently differ from each other, as I have included famous and wealthy biotechnologists who have access to capital, research facilities and political power, and a network of citizens who are trying to apply a DIY and low-capital approach to biology. Craig Venter's Sorcerer II made DNA hackable by insisting on informational metaphors, deterritorializing genomes and circulating them in a heterogeneous network of firms, universities, foundations and mass media. Venter bypasses Mertonian ethic and recombines Victorian gentlemen scientists' culture with a hacker component. He proudly announces that his greatest success is that he managed to get hated by «both worlds»: academic and corporate. Yet his hack is directed towards profit and entrepreneurship, as Venter tries to exploit openness in order to participate in a different form of biocapitalism in which data circulation is as important as data gathering and management. With GISAID, Ilaria Capua made the DNA of viruses hackable by removing it from Big Bio secret world, a world where an old-style priesthood decides who can access Hulking Giant databases. Opening up the access to avian flu data was achieved by restoring the modern science ethic and upgrading the image of a rebel and revolutionary scientist with contemporary features taken from the open source and free software world. She broke the moulds, she refused the secrecy of an «outside world bureaucracy» in order to push a giant-sized institutions to change. The explicit hacker references and practices of DIYbio talk about opening up biology to public participation but also to new forms of grassroots entrepreneurship. Their hacks are not merely a political critique against Big Bio but rather an attempt at finding new and better ways of accessing cells and DNA. DIYbio is a very complex case, and the explicit hacker component it shows encompasses many different facets of hacking: the rebel one, the entrepreneurial one, the antimonopolist one, the individualist and the collective ones, and so on.

As I argued above, in times of crisis and change the need for a reconfiguration of different aspects belonging to one or more pre-existing cultures becomes more insistent in order to answer the urgent need for new strategies of action. Thus individuals can mobilize cultural characteristics and operate a remix between an old culture, already accepted and embodied in a recognized set of practices and norms, and ready to be used; and a different set of cultural features that belongs to other social groups. The stories I have analysed are powerful precisely because they all narrate one, or perhaps several possible futures of change, openness and horizontality in a field as difficult, criticized and soaked with Big Bio practices as biotechnology is. As I argued above, they represent very different worlds, such as academic and public funded science, freelance research able to raise money from corporations, governments and venture capitalists, and amateur research who has ambivalent relationships with universities and firms. Yet putting them together under the umbrella of hacking, I point out the emergence of a new open science culture: a new form of public image that scientists can use to build new strategies of action and better interact with the peculiar socio-economic configuration of contemporary biological sciences. As I argued above, the old Mertonian ethic of the 20th century academic scientist is still at scientists' disposal, but in order to use it as a powerful tool it needs to be remixed with components coming from cultures directly related to computers and information technologies. The spreading of legal and technological tools that enact new forms of data and knowledge sharing needs a cultural adaptation that Merton can not provide. Open science needs new social, communicative and political practices and a new incentive system. Old media such as peer-reviewed scientific journals are not always an adequate answer to new societal and economic needs. In hi-tech gift economies, data potlatchs and participation are part of corporate economic models as well as ways to enrich the commons and challenge monopoly power and its informational land revenues.

Of course, the results I found in the three cases I analysed here are not easily generalizable. They are just a few examples, yet I think they represent a crucial tendency of contemporary life sciences. Beyond their individual results, these cases can be interpreted as a symptom of the emergence of the new open science culture in biology and genomics that I point out. Yet very similar sets of public virtues can be found in several other biotechnologists. Indeed, this culture related to open source models and open genomics exists in biologists working in different institutional settings and also in different scientific sub-fields such as personal genomics, synthetic biology and metagenomics. During the years in which the events I analysed took place, the scientific and media stages have seen the appearance of other biotechnologists using the same metaphors, exploiting the same images of science, keeping a balance of information disclosure and privatization, and exploiting the media and the Internet in the same way. Examples that appeared in the mass media in the post-genomic era (the first decade of the 21st century) include several biohackers according to the meaning I have given that term. The «open source junkie» George Church from Harvard, also nicknamed «information exhibitionist» given his attitude for total data disclosure, is the director of the open source Personal Genome Project and is involved in many startups in the field of genomics. Another is Drew Endy of the MIT Biobricks Project, with his ideas for «DNA hacking» that he has also presented in public meetings such as the Chaos Communication Congress of Berlin, one of the most famous hacker gatherings on the planet.[81] Church and Endy are two of the most famous supporters of open genomics and citizen biology. The Icelandic deCODE Genetics of Kari Stefansson sells customized genomic services with the motto «Know your code», «discover the secrets of your DNA» and «take a voyage of discovery.»[82] 23andMe, the Google genomic startup, urges you explicitly: «Unlock the secrets of your DNA. Today.» But besides cracking the code of your genome, 23andMe asks you to share your genetic, phenotypical and medical data in its social media website. The Spencer Wells' Genographic Project,[83] a massive collection of genomic data started in 2005, is a joint venture between National Geographic and IBM and it brings together dozens of universities and research centers all over the world. This project, half scientific journey, half media production, is based on the selling of a personal DNA testing

[81] http://events.ccc.de/congress/
[82] www.decodeme.com
[83] www.genographic.nationalgeographic.com

kit whose results are made publicly available through an open source database. Also, in these cases, the informational and promissory metaphors surrounding genomes feed on the changes of a biology in which scientists are managers of open genetic information, providers of customized services, direct interlocutors for the needs of citizens outside of Big Bio. They are interpreting the same shifts in the relationship between genetics and society I have pointed out above. The overlapping of openness, anti-bureaucracy, hedonism and sometimes even explicit references to hacking, are becoming common in today's biologists.

Thus I think this emergent class of biohackers is related to a new possible type of interaction between scientists' practices and biology's social contract. A new open science social contract would restore some sharing practices that characterized 20th century academic research. But they would be transformed, broadened and improved by web technologies and the widespread diffusion of open and peer production. At the same time, it would include practices of closure such as patents and copyright. Different forms of intellectual property rights would coexist in an environment inhabited by creatures as diverse as companies, universities, public agencies, start-ups and new institutions such as citizen science projects. More importantly, the new open science culture related to this social contract would maintain its political ambivalence. As I argued above, it works in corporate and public settings as well as in citizen and patient groups' experiences.

Neoliberal revolutionaries

In conclusion, I think that the type of mobilisation and reconfiguration of the public ethic of science that I pointed out in this work is more adapted to the needs of 21st century life sciences. As an initial and simpler explanation, the emergence of similar types of scientists can then be interpreted as a response to a legitimacy crisis. With their insistence on openness, rebellion and antiestablishment critique, these biologists are making the public image of genetics "moral" again, an image that badly needs a renewal after the legal, political and societal clashes it suffered because of the rise of the anticommons. This need is not limited to academic scientists: Janet Hope directly links public relation strategies and the use of open source models, the latter being «an investment in the firm's overall brand and reputation (...) a deliberate strategy to enhance the reputation of companies in the biotechnology and related industry» (Hope 2008, p. 262).

But to try and dig deeper into possible kinds of cultural explanations, I want to illustrate other links between the analysis I have conducted and some of the societal, legal and economic transformations current biological sciences are undergoing. In fact, biohackers' mobilisation of ethics can also be interpreted as a way to better interact and position themselves within the current socioeconomical configuration of biological sciences. Indeed biological innovation now takes place in increasingly more complex and mixed configurations, in which open data policies and open access coexist with different, and more strict, sets of intellectual property rights (Benkler, 2006, Hope, 2008). Both academic and industrial research (provided that it is still possible to clearly separate them) have increasingly been using diverse and mixed approaches to intellectual property, and in some cases - such as database management - strictly proprietary models are seen as no longer sustainable. Thanks to open and free input of voluntary contributors, participatory processes of governance, and universal availability of the output, open and peer production might prove to be more productive than centralized alternatives (Hope 2008, Bauwens 2010).

Finally, to continue using the hacker metaphor, we could argue that these biologists are hacking the rules of biology. Their active approach to information allows them to participate in the transformation and shaping of the current proprietary structure of science. Their struggles against Big Bio priesthoods are a challenge against the current distribution of power among science's institutions. In this sense, their stories could be a model for transformations that are also taking place within other innovation regimes such as software, hardware, technology, and so on. In many fields of information and knowledge production, actors are actively transforming and building their own infrastructures - whether they are technological or legal (licenses). Pierre Bourdieu (2004, p. 63), while referring to epistemic (and not institutional) revolutions, highlighted that the revolutionary scientist does not only head towards a victory. Scientists can be willing to change the rules of the game: «revolutionaries, rather than simply playing within the limits of the game as it is, with its objective principles of price formation, transform the game and the principles of price formation». Christopher Kelty, who referred to a broader world, not limited to scientific research but related to free software and free culture (2008, p. 302), has argued that the new wave of open and peer production projects related to the emergence and spreading of free software culture are «a new response to a widely felt reorientation of knowledge and power». However, the direction this reorientation will take and the role of scientists' culture in this process is still to be deciphered. Open science advocates somehow foresee a Mode 3 Science, or an open science renaissance enacted by scientists' willingness to share data and knowledge, new information and communication technologies, and a new system of incentives based on the acceptance of the open source model by both public funded research agencies and private corporations (Benkler 2006, Hope 2008).

The stories I have presented here surely represent a shift towards more open approaches both in the public and in the private sector. They are rebellions and challenges to the incumbents of the current life sciences system, what I have called Big Bio to highlight the role of big corporations, global universities and international regulatory agencies. Yet they also show how this open science is strictly related to entrepreneurship, academic capitalism and neoliberalism. Of course, the new and emergent public ethic I have described in this work is to be compared with capitalism's «new spirits» characterized by their emphasis on cooperation, freedom from bureaucracies, and openness and horizontality (Barbrook and Cameron 1996, Boltanski and Chiappello 2005, Himanen 2001). Open source models and open science acquire public value because they are an important part of the configuration of the relations between research, society and the market. Yet I think the cases I have analysed represent two opposite tendencies within this framework. One towards an individualistic culture of openness both in information circulation and in capitalist competition, a new open frontier for science entrepreneurship in a new territory of accumulation. The other towards a collective, peer produced biology wher open sharing is coupled with open participation and a discourse of democracy. Both these tendencies are somehow part of a countersymbolic order, since they challenge today's forms of Big Bio's concentration of power. But neither of these tendencies excludes a crucial role for entrepreneurship and profit. Genes, differently from Mode 1 science and Mertonian culture, can always be objects of private interest. The ambivalent claims we have heard all along the history of information society – all information must be free! – echo again in labs and in the media arena.

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