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The translations and the organizing of scientific practices in R&D biotechnology

As translações no organizar das práticas científicas em P & D biotecnológica

Organización de prácticas científicas de Investigación y Desarrollo en biotecnología

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Abstract

Considering the scientific practices related to Research & Development in biotechnology and, based on the assumptions of Actor Network Theory (ANT), this study aimed to describe the main translations that influenced the composition of an actor-networks, reflecting on the organizing practices in a scientific laboratory Research & Development of Northeast Biotechnology Network (Brazil). The methodological procedures were based on the historical approach of biotechnology under study from an ethnographic posture. The composition of the corpus was organized in the form of reports, observing the historical passages. The history of biotechnology has been reported between the plots of design, patenting and commercialization practices, highlighting the creation of heterogeneous actors' networks. Finally, he emphasized the influence of laboratory scientist's leadership in the way of organizing of scientific practices.

Keywords: Translation; Scientific practices; Actor-Network Theory; Biotechnology

Resumo

Considerando as práticas científicas relacionadas a Pesquisa & Desenvolvimento em biotecnologia e, com base nos pressupostos da Actor Network Theory (ANT), esta pesquisa teve por objetivo descrever as principais translações que influíram na composição de uma rede-de-atores, refletindo sobre o organizar das práticas científicas em um laboratório de Pesquisa & Desenvolvimento da Rede Nordeste de Biotecnologia (Brasil). Os procedimentos metodológicos se basearam na abordagem histórica da biotecnologia sob estudo a partir de uma postura etnográfica. A composição do corpus foi organizada na forma de relatos, observando as passagens históricas. A história da biotecnologia foi relatada entre os enredos das práticas de concepção, patenteamento e comercialização, evidenciando a constituição de redes de atores heterogêneas. Por fim, enfatizou-se a influência da liderança da cientista do laboratório no modo de organizar das práticas científicas.

Palavras-chave: Translação; Práticas científicas; Teoria Ator-Rede; Biotecnologia

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Resumen

Teniendo en cuenta las prácticas científicas relacionadas con I+D en biotecnología y con base en los supuestos de la Teoría del Actor-Red (*Actor-Network Theory* - ANT), en este estudio se pretende describir los principales movimientos que han influido en la composición de una red de actores, así como evaluar la organización de las prácticas científicas en un laboratorio de I+D de la *Rede Nordeste de Biotecnologia* (Brasil). Los procedimientos metodológicos se basan en el enfoque histórico de la biotecnología en cuestión desde un punto de vista etnográfico. La composición del *corpus* se ha organizado en forma de relatos o descripciones, con la observación de pasajes históricos. La historia de la biotecnología ha sido relatada en el contexto de las prácticas de creación, patentes y comercialización, lo que pone en evidencia la creación de redes de actores heterogéneas. Por fin, se observa la influencia del liderazgo de la científica coordinadora del laboratorio en la forma de organizar las prácticas científicas.

Palabras clave: Movimientos; Prácticas científicas; Teoría del Actor-Red; Biotecnología

Introduction

During the last decades, Rabinow's work (1999) has been based on the assumption that the term "life" has been undergoing a modernization process which is parallel to that occurred to the word "society" in the last century. When discussing the "modernization of life", the author emphasizes that we live in a time when new practices on what being *anthropos* means are in production and circulation. The author converses with the social studies of science, developed by, among others, Thomas Kuhn, Bruno Latour and Donna Haraway, a dialogue which predominantly reflects the everyday practices in scientific laboratories and focuses on how the major abstractions of "science" are also products of these local practices (Biehl, 1999, p. 14).

Rabinow (1999, p. 9) proposes that contemporary anthropology create new ways of engaging in research procedures of scientific culture and "analyze the *logoi*, science and understandings that are emerging around the constitutive material of life." With its ethnography of science, the author points out that this is also culture, real and constructive, which does not exist outside of relations of knowledge and power. The author based his questions on scientific reason when taking the contemporary reason as his anthropological object and suggests viewing anthropology as nominalism: "The reason, in spite of whatever it may be, is a social relation historically locatable, an action in the world – a set of practices" (Rabinow, 1999, p. 16). For Rabinow (1999), once such understandings have been incorporated, the field is ready for re-evaluations and taking new directions, and ethnography is a key step in this process. Thus, the author suggests approaching the "scientific places" where new forms/events emerge, and investigating how these forms/events catalyze actors, things, temporalities/spatiality into a new assembly of the social, thereby producing new skills (Rabinow, 1999, p. 14).

A similar discussion is articulated by Latour (2001), as he construes the social as a temporary/momentary organization, built by associations of elements materially and discursively heterogeneous, human and non-human, such as objects, machines, humans, animals, texts, ideas, organizations, among others (Law, 1992, 2007). To Latour (2001), the only way to understand the reality of scientific studies is to follow what they do best, that is, to pay attention to details of scientific practice. In Latour's view (1997), the studies focusing on practices have an empirical character as they focus on the moment at which researchers exercise their activities. Knorr Cetina (1999) agree to discuss the scientific studies focus on practices from their organizing (practice as its organizing). And in that sense, Latour (1997) believes that the scientific laboratories are excellent places, where it is possible to understand the production of certainty. Following this theoretical line, a growing concern of organizations in countries with late industrialization has emphasized issues related to the ability to recognize and manage the resources and skills necessary for the research and development process (R&D).

On the other hand, much of the academic literature pertaining to this debate on the issues of technological innovation addresses issues related to the analysis of policies that facilitate or hinder its spread in the markets and the organization of R&D activities on which they are based. These discussions relate to the debate on the complex interweaving of Science and Technology (S&T) that characterizes the modern world (Nelson, 2006). In these terms, the links between C&T which began to take place a century ago led to the emergence of R&D laboratories as one of the main places where efforts towards innovation occur. These entities, dedicated to technological advancements and constituted by scientists and engineers, established a close link to certain production companies and sectors of companies whose R&D often rely on external sources such as universities and government laboratories (Nelson, 2006).

Nelson (2006) discusses the role of knowledge in the efficiency of R&D, emphasizing that most of the studies that focus on the issue of invention and innovation have shown a satisfactory grasp of why and how the capacity of an inventor for appropriating the return of his own invention affects the susceptibility of inventive effort and the efforts in R&D to the demand side factors. However, it has been a great deal harder to reach a solid understanding of the factors that influence the supply of inventions or technological advancement. The preposition that the author raises is that inventions advance more quickly and more effectively in areas where technological knowledge is solid than in areas where it is weak. Knowledge enables to the attainment of broader advance from certain efforts in R&D. Alternatively, solid knowledge reduces the expected costs of any R&D results, while increasing the efficiency both by empowering R&D to work with a better set of potential projects and for

making this set closer to the real demands and needs of the market. On the other hand, "the demand for an invention without knowledge skills needed to perform it, may draw efforts, but not a success" (Nelson, 2006, p. 248). From the author's point of view, this question, of course, is partly empirical, but it is also conceptual, requiring a broader understanding of the effects, the sources and the organization of knowledge on which R&D efforts are based.

In line with this discussion, our research makes use of Actor Network Theory (ANT) approach (ANT), "Sociology of Associations", also called "Sociology of Translation", which originated from the need for a new social theory adapted to the S&T studies, whose main authors are Callon (1986), Law (1986, 1994), Bijker and Law (1992), Latour (1994, 2001). To Alcadipani and Hassard (2010), ANT, despite having originated outside the scope of organizations, in anthropological and sociological studies, has been recently used as a perspective to investigate organizational processes, including Brazil (Alcadipani & Tureta, 2009; Andrade, Cordeiro Neto, & Valadão, 2013; Cavalcanti & Alcadipani, 2013; Ipiranga & Matos, 2014; Ipiranga, 2010).

However, despite the recent popularity of ANT in Brazil, some research into databases EBSCO, Emerald, Science Direct, reveals that there are few studies developed from the perspective of ANT in the S&T which focused on the scientific practices in R&D laboratories integrated into academic networks directed to the biotechnology sector. Our research is inserted in this gap, with the intention to contribute to the advancement of knowledge in the area.

For Latour (1994, 2001), the only way to understand the reality of scientific studies is to follow what they do best, that is, to pay attention to details of scientific practice – a hybrid that lies halfway between the line connecting the object polo (thing-in-itself, nature) to the subject polo (men-between them, the social construction) and is mediated by laboratories, in which an object and a context are built. Thus, to Latour, nature and society would be the effects of heterogeneous networks between humans and non-human elements that must be considered at the same time and at the same analytical plan, which is called the principle of symmetry (Law, 1987). Given this premise, the scope of this research lies within the organization of scientific practices related to the biotechnology "Vaccine Development Using a Bundle as Biofactory". This biotechnology was developed by the scientist coordinator of the Laboratory of R&D Human Biochemistry, member of the Northeast Biotechnology Network (RENORBIO, 2012).

Considering the methodological assumptions of ANT combined with historical analysis of scientific practices related to biotechnology under study, the aim of this study is to describe the main translations that influenced the composition of an actor-network, human and non-human, reflecting upon the organizer of scientific practices which prompted the R&D efforts in a biotechnology RENORBIO lab.

Scientific practices and evolution of scientific field

Kuhn (1998) and his followers claimed that "normal science" is a practice in which scientists conduct their discussions with reference to examples which are common to themselves. When considering that the "rationality practices" constitute a broad, hitherto unchartered territory, Rabinow (1999, p. 116) works with the hypothesis that it is possible to analyze reason in the same way as other ethnographic objects are analyzed, i.e., as "a set of social practices in complex pragmatic relations with congener symbols".

Ethnographic studies more restricted to laboratory practices, such as Latour (2001), Latour and Woolgar (1997) and Law (1994), apart from questioning a positivist understanding and idealistic science as a unified activity that achieves a cumulative understanding of nature, also aimed to demolish the very idea of science.

In turn, Canguilherm (2009) conceptualizes science as a verified discourse in a delimited sector of the experience. So, for Canguilherm (2009), the history of science is the history of an object, a historical discourse that has a history, while science is the science of an object that is not a story and which has no history. Rabinow (1999, p. 126) explains that, by using its methods, science divides nature into objects, which are, in a sense, secondary but not derivatives. It can be said that they are both constructed and as well as discovered.

Based on this statement, Deleuze (2005) shows that the best example of the so-called era of "surhomme" or "after-man", as defined by Rabinow (1999, p. 136), in which the "finite", as an empiric entity, gives rise to a set of forces and forms classified as "fini-illimité", is the DNA: an infinitude of things can take place, as attested by the discovery of the four bases constituting the DNA. And that is exactly why, according to Rabinow (1999), new practices, especially within the science of biotechnology, are going down in history and are emerging in the fields of work and life.

In the biotechnology field, Rabinow (1996), citing the polymerase chain reaction example – PCR's technique (technique which enables the DNA segment identification and their multiplication in a short period of time), emphasizes the need for historical analysis of an invention that can be distinguished from legal definitions of what is an invention. To formulate a concept is not enough, as scientific advances include demonstrating that the concept can be formalized in a practice.

For this work, Rabinow (1999, p. 186) suggests the description of the triad "technique – concept and experimental system" used in daily work and which is implied in any scientific advance. The author shows that the relationship between these elements is variable and the form taken at a particular time by this relationship is an empirical question. Rabinow (1999) maintains that, after the development of an experimental system, in which the concept can be transformed into practice, and be experimentally formulated, results that meet the standards of publishable evidence should be produced. Anyway, "for a practice to become scientific, it is necessary to put it in a written form which is in accordance with the community standards" (Rabinow, 1999, p. 190).

On the other hand, according to Rabinow (1999), a description held in the biotechnological *milieu* could not overlook an assessment of the particularity of biotechnological inventions. To achieve this feature, Rabinow (1999, pp.

186–187) suggests using the term "machine", as the analytical framework proposed by Gilles Deleuze (2005): "Neither mechanical nor organic (. . .) the 'machine' is a close-collection of human–instruments–animals–things. The machine precedes these terms, since it is the abstract line that runs through them and sets them working". In this sense, the term 'machine' refers to a complex, heterogeneous and contingent (technical, scientific, institutional, discursive, cultural) event and points to the emergence of new practices and new actors (Rabinow, 1999).

Rabinow (1999) reminds us that, despite the fact that the aforementioned triad possesses a heuristic and useful character, it separates the research object from the specific *milieu* in which it emerged, namely the context of relations between the science of biotechnology, university (academia), enterprises and the market (industrial science). Such separation, the author emphasizes, might be something acceptable for a bio-scientist, to whom the history of techniques, concepts and experimental systems used in his daily work should usually be placed in parentheses in order to continue this work. However, for those seeking to understand what bio-scientists do, this is an unacceptable limitation, which is widely demonstrated by social studies of science (Rabinow, 1999, p. 186).

In this context, Rabinow (1996, p. 162) shows that during the past few decades there have been several factors that reshaped the scientific practice with different implications for these changes, such as the emergence of personal computers, the change of patent laws, the massive influx of venture capital in high technology. In this sense, biotechnology can be constructed in terms of increasingly dense interconnections between systems-of-actors in different dimensions (scientific – technological, social and economic).

According to Rabinow (1999), the authors that write about these new institutional relations tend to consider the general institutional rules of the biotechnology industry to be basically like those of other businesses, governed by profit, efficiency and productivity. On the other hand, while attention remained focused on the impact of industrial models of the academia, the opposite exchanges were less emphasized, which will be discussed in the next section.

ANT: The organizer of the translations

Latour (1994) emphasizes that science represents the nonhuman, but it is forbidden to appeal to politics. On the other hand, politics represents the citizens, but it is forbidden any relationship with nonhumans produced and mobilized by Science and Technology. In these terms, the author shows that the "political ecology" leads to nature in its relations with society, but this nature becomes recognizable through science and scientific production, which, in turn, is formed by networks of tools, defining the interpretation of the specialties, disciplines, protocols, being distributed in databases and argued through the scientific societies (Latour, 2004).

This argument and spread of scientific facts in time and space trigger, according to Latour (2010), a fantastic increase in materials and elements to be interconnected. In turn, this increase is necessarily linked to the fact-builder of the problem: "how to spread in time and space"? (Latour, 2010, p. 177). To him, the only way to understand the reality of scientific studies is to follow what they do best, that is, to pay attention to details of scientific practice (Latour, 2001).

According to Latour (1997, p. 29), in order to achieve scientific practices, it is necessary to go beyond the scientists orderly and sophisticated accounts and observe "the disorderly metalanguage that blends closely in practice." In this sense, scientific practice is more about creativity and construction than about discovery. For Knorr Cetina (1999), scientific studies focus on the practices from its organizing (practice as its organizing). The practices investigate scientists at work in contrast to the stories of the ideas and the structure of institutional theories of science. Latour (1997, p. 160) borrows Knorr Cetina's concept (1999) to emphasize the "idiosyncratic, local, heterogeneous, contextual and diversified" character of scientific practices (Latour & Woolgar, 1997, p. 160), which are made up of "local and unspoken negotiations, constantly-alterable reviews and unconscious or institutionalized gestures".

As emphasized previously, Rabinow (1999) raises the question that there is a tendency to consider discussions on the impact of industrial models on the academia, and ignoring the exchanges from the academia to industrial models. Along the same lines is the question posed by Rabinow (1996) related to biotechnology, which should be built in terms of increasingly dense interconnections between the various scientific – technological, cultural, social and economic actors.

In this sense, when we shift the focus of discussion towards the academia, we are faced with the question of how to trace in the Science and Technology field – in which R&D efforts proliferate, the boundaries between the groups are uncertain, with a wide variety of elements and entities to consider – new combinations of associations between the actors?

Given this uncertainty, Latour (2008, 2010) proposes the action in two seemingly contradictory directions: (i) enlist people so that they participate in the construction of scientific facts; and (ii) monitor the behaviour of these people to make their actions predictable. A resolution to this contradiction would be the idea of translation, i.e. "the interpretation given by the builders of the facts to their interests and to those of the people they enlist" (Latour, 2010, p. 178). In addition to the linguistic meaning of "translation", the term semantically carries a geometric idea of transposition from one place to another, "to translate interests means, at the same time, to provide new interpretations of these interests and channel people into different directions" (Latour, 2010, p. 194).

In this sense, according to Latour (2010), whatever you do and wherever you go, it is necessary to go through the position of human and non-humans actors and help them to promote their interests. The greater the number of connections between different elements, the more likely the transformation resulting from such positions. Such translated positions are observable as a slow movement from one place to another, mobilizing and tying issues of restricted domain to those far more spacious, subtly weaving a network that may be useful to keep the different actors in its nets (Latour, 2010, pp. 179–198).

The author maintains that the word network indicates that resources, whether human or non-human, are concentrated in a few places "the loops and the knots-closely intertwined – like thread and cloth". The heterogeneous network corresponds to "a way of suggesting that society, organizations, agents and machines are all effects generated by networks of various (not only human) materials" (Law, 1992, p. 380). These connections between the network-of-actors transform the resources scattered on a web that seems to extend everywhere (Latour, 2010, p. 294).

In this sense, in the ANT approach, the role of human actors is not limited to that of mere informants; this approach restores in the agents the ability to create their own theories about what makes up the social domain. The task is not to impose some order, but "to follow the actors themselves" (Latour, 2000), adding reflexivity to their practices, recovering the problems and the course of their research and describing from these, in what had become the collective existence in the hands of humans and non-human actors, which methods have been developed and which translations and associations have been established. The point is to make a new re-compilation and re-assembly of the network-of-actors concerning the non-social domain, thus achieving an understanding of how the social is generated (Latour, 2008). In this sense, the use of ANT appears to provide an analytical tool for the study of the organizing practices as effects of a heterogeneous network of human and non-human elements (Alcadipani & Hassard, 2010).

Thus, scientific studies, rather than separate pure science from pure politics, reveal, a posteriori, the connections between science and politics. Latour (2001) explains that the idea of translation enables some understanding according to a guidance system and alignment of the flows coming from politics towards science, and others coming from science and following the current references. In this sense, the translations resulting from current references relate to the work of the actors that change, modify and translate their controversial interests, setting up a network-of-actors (Callon, 1986; Latour, 2008).

In Latour's (2001) view, the construction of scientific facts is a collective process that can be understood as a circulatory system in which the various human and non-human actors interact and generate new associations. For this, the author proposes a model consisting of five lines that intertwine simultaneously on a major axis (the *bonds and links* circuit). In order to understand the construction of scientific facts, the author maintains that it is necessary that the five circuits be considered in the analysis, in order to achieve a reconstruction of the network of scientific facts, between these circuits: (i) *World's Mobilization:* this first circuit concerns the insertion of non-human actors in the discourse, these being the body of material instruments available to scientists, with a view to arguing in favour of their research; (ii) *Autonomy* (pairs): In order for a researcher to gain credibility, peers – who can judge and criticize their work are necessary; (iii) *Alliances* (allies): Only from associations and organizational, political and scientific alliances can a discipline become autonomous; (iv) *Public Representation:* The fourth ring refers to the researcher's need to have important relations with the public, such as the press, the media and citizens. Public opinion influences other circuits thereby increasing the power of persuasion; (v) *Bonds and links:* The fifth circuit is a central point in the network, connecting to the four other circuits, as it holds together many heterogeneous resources.

Latour (2001, 2008) believes that the scientific practices must be crossed by translations between these rings, in the sense that the scientist should act in each one of the fields. Only from these movements can controversies be articulated and the results of their researches legitimated among their peers and the public sphere.

In recent decades, the Organizational Studies began to make use of different paradigms from the objective reality of the dominant functionalism (Burrell & Morgan, 1979). Robert Cooper (1976) enabled the understanding of organizations as diffuse and procedural phenomena, a premise which contradicts the short-sighted view of classical epistemology. This perspective leads to thinking about organization not behind closed doors, as something already established, but rather as open processes in constant construction.

One way to legitimize this analysis of organizing entails an investigation of its historical construction. This understanding draws on the discussions gathered in the so-called "historic turn", where the (re) construction of the facts allows the practices of organizing in cultural and historical form (Clark & Rowlinson, 2004). Cooke (1999) goes on to show that this social and political contextualization of the organizational knowledge unravels the underlying historical plot underlying the present or, as Serres (1996, p. 86) emphasizes: "The time of history is rather complex, simultaneously referring to the past, the present and the future". The "historic turn" and its proposals soon arrived in Brazil. In this area, Vizeu (2010) proposes studies emphasizing the historical understanding of the organizational phenomenon and its specificities within the Brazilian context. Some other scientific work relates history, historiography and organizational studies (Costa, Barros, & Martins, 2010), daily life and history (Barros & Carrieri, 2015) and historical perspectives of business schools in Brazil (Fernandes, Bezerra, & Ipiranga, 2015). In this sense, the translation studies with an analysis developed based on a historical perspective contribute to the Organizational Studies area, focusing on practices and processes of organizing in a space-temporal context (Bloomfield & Vurdubakis, 1999).

On the other hand, some studies in Brazil have emphasized examples of experiences that seek alternative ways of thinking organization "out of the possible limits" by criticizing the business logic and shedding light on the processes about other forms of producing organization (Carvalho, 2006; Misoczky & Vecchio, 2006). In this regard, analysing the "organizing" by ANT through a historical perspective can help to increase the understanding of the arrangement and temporary rearrangement of human and non-human actors (Bloomfield & Vurdubakis, 1999), seeking to understand how this heterogeneous network is in a process of on-going construction (Alcadipani & Hassard, 2010).

Methodological procedures

The method of qualitative nature drew upon the historical approach from an ethnographic posture. According to Peirano

(2006), the contemporary anthropological production finds shelter in several places, characterizing itself by "multiple locations" (multi-sited) discipline. In that sense, "the ethnographic-inspired studies are no longer anthropology" (Peirano, 2006, p. 33), since they are based on the work of researchers who are not specialized in Anthropology. Within this context, the ethnographic posture of our research proves to be relevant, in view of the magnitude of relationships to be revealed.

To Rosenberg (2006), a technology should be understood as a social process and the historiography of its development reveals the key aspects to its understanding. Barnes, Bloor, and Henry (1996), in line with this perspective, emphasize how and why the sociological analysis becomes an essential complement in the understanding of scientific knowledge, and in this context, the main method should be based on the submission of historical cases studies. Latour (1997, p. 103) also refers to the importance of studying the historical genesis to analyze in detail the social construction of a scientific fact.

In the context of Science & Technology, Latour (2004) stresses that science is a culturally-constructed institution and the ANT is, first and foremost, a method, a way to follow the construction of scientific facts. Thus, the adoption of ANT in this research aims to map out the organizing of translations across heterogeneous networks through which they are transported, describing their plots (Latour, 2004). Based on the confrontation of theory referred to in this article and the historical-empirical corpus constituted, we carried out a historical analysis of technology, considering the period between the years 2002–2014 and combined with the three analytical schemes, among which:

(1) The triad developed by Rabinow (1999): *technique* (the artefacts used), *concept* (conception of the technology itself), and *experimental system* (how the technique connects itself). In relation to this triad, the author highlights that scientific objects are not only discovered but also built and the history of a certain technology allows the observation of scientific progress and the consolidation of the technique in an experimental system.
(2) To map out the translation's organizing, the methodological principles proposed by Latour (2000) were considered: (i) Seeking a gateway into the laboratory, the place where scientific facts are built; (ii) Definition of the mechanisms of inscription, namely: instruments, equipment, apparatus, graphics and scientific tests, structures and non-human actors that enable a visual display of technology; (iii) Identification of the types of controversies which arise; (iv) Tracking of controversies by identifying the spokesmen, the directions and translations of interest (the blocked paths and shortcuts), the funding (subtle control of opponents' movements – laboratories and counter-laboratories); (v) Identification of the enlistment of new supporters, new compositions (Increase in negotiation margins and complexity of the "machine") and description of new transforming elements; (vi) Mapping translations chain (points crossings) and the organizing of actors' network.
(3) Lastly, with a view to guiding the mapping of translations in organizing the network, we considered the five circuits of the "circulatory system of scientific facts" approach, as described in the previous item (Latour, 2001).

The mapping of network-of-actors was based on the network idea, as an expression used for checking how much energy, motion and specificity are able to capture the empirical reports. Network is a concept, not something that exists outside. It is a tool to help describing something, not something you are describing (Latour, 2008).

Over a period of approximately 10 months, research activities were carried out for the composition of the empirical *corpus* (Bauer & Gaskell, 2002) by means of documentary survey, research reports and laboratory notebooks, technological information, patent reports and institutional documents. Concomitant to this documentary survey, the direct observation procedures was conducted (Lynch, 1993, p. 91), inside the laboratory, with systematic notes in field diary.

Considering the idea of "extensive laboratory" (Callon, 1989) the relationships between the actors and institutions outside the laboratory under study were also traced, thus composing a panel of key actors. A series of in-depth interviews at different times of the research was performed, with the lab coordinator scientist (PhD in Biology and productivity researcher at National Council for Scientific and Technological Development – CNPq), who developed the biotechnology under study, together with her research assistant (PhD student in biotechnology RENORBIO). Adjacent and external institutions to the laboratory were involved in the research, the "Technological Innovation Network Centre of Ceará – REDENIT/CE", especially on issues related to the protection process, transfer and commercialization of technologies developed in RENORBIO's participating institutions, and thus the Coordinator of REDENIT (PhD student in Biotechnology at RENORBIO) was interviewed.

The material compiled during the *corpus* composition was organized in the form of reports and plots observing the historical passages. We also used the social networking analysis software's UCINET (version 6.2) and NETDRAW (version 2.0) in order to better visualize the translations of passage points built between the actors-in-network along the different circuits and different historical phases of the biotechnology under study.

The translation networks and the history of the organizing of scientific practices R&D: "Vaccine Development Using a vegetal system as Bio factory"

The history of biotechnology was built, based on the analytical schemes that helped in the construction of historical plots. As a gateway, and, aiming to track and map out the translations in network, we selected controversies related to the practices leading up to the commercialization of biotechnology under study, given that, in order to become an innovation, technology has to reach the market (Nelson, 2006). In this sense, it establishes the historical period of study between the years 2002 and 2014. Later, the spokesmen and their controversial concerns were identified, namely those who speak on behalf of the network, who eventually synthesize the expressions of human and nonhuman actors (Latour, 2000, 2001).

Considering the scientific practices involved in the controversies prior to the commercialization of the biotechnology under study, the following main spokesmen were identified: a scientist coordinator of the laboratory of Biotechnology Northeaster Network of Human Biochemistry – RENORBIO, responsible for the development of technology; his research assistant for acting in the biotechnological spin-off created afterwards and the Ceará REDENIT's coordinator.

As registration devices used for the objectification of the networks that carried scientific practices at different historical stages of biotechnology in the study are: the alliances built, the released resources and the equipment obtained, the terms of confidentiality signed during the process, the patent application filing document, the contract of the spin-off constitution and the transference from the scientific laboratory to the incubator of the State University of Ceará (UECE) as RENORBIO's participating institution (Latour, 2000).

In the historical recovery that follows, we opted for the mix of reports and plots of identified controversies, spun from the description of the translations and concatenation of scientific practices in an attempt to map out the organizing of the network-of-actors at different times mapped between the years 2002–2014 (Latour, 2008). To display the historical reports and plots, they were organized according to the triad developed by Rabinow (1999), with regards to the evolution of scientific fields: technique (artefacts used); concept (design of the technology itself), and; experimental system (how the technique connects).

The technique and its artefacts

The construction of the plot is based on the premise that the practice of science lies halfway between connecting the pole of the object to the pole of the subject, being mediated by laboratories, in which an object and a context are constructed (Latour, 1994). The object in focus thus relates to scientific practices regarding the biotechnology under study. The R&D laboratories are shown as the very *locus* for understanding the reality of the construction process of the scientific fact, which takes place through the monitoring of scientific practice. In this context, as previously explained, the first circuit, according to Latour (2001), called *World Mobilization*, concerns the insertion of non-human actors in the discourse, these being the body of material instruments available to scientists, in order to argue for the sake of their research. As the observations reported in the journal field and reproduced below.

> (. . .) The structure of R & D Human Biochemistry laboratory is characterized by a set of rooms, between these: the cell culture room, the biotechnology consulting room and microbiology room. Among the equipment used, the centrifuge and the 'shake' incubator stand out as critical to the research conducted. In addition, there is a reasonable number of tubes and pipettes, glass and plastic containers of different colours, shapes and sizes, with liquid, gaseous and solid reagents, accommodated on the numerous shelves and the white-tiled countertops of laboratory rooms; sinks and ovens, scales and measuring instruments; transformers of different voltages, refrigerators and freezers; a set of computers and microscopes; posters with information about biosafety. (. . .) And finally, we come to the room intended for the completion of the processes related to scientific practices of molecular biology. That is where DNA extraction/RNA for the transformation of the plasmid are performed (described in the Notes field diary).

Considering the motivations that drove the development of biotechnology in the search for a solution to the problem of dengue, the scientist's accounts revealed that clinical tests commonly performed (haematocrit and platelet count) provide useful information but do not confirm the diagnosis of dengue due to the fact that changing blood levels may be linked to other infections. Thus, the scientist was faced with a gap in knowledge regarding the need for an early diagnosis of dengue:

> (. . .) Our research is directed to address the problem of early diagnosis of dengue (. . .) it is very sad to see people dying of dengue every day (. . .) simply because a diagnosis could not have been made? (Scientist's account).

In addition, the scientist narrates episodes related to his personal experience that contributed as a motivator to develop biotechnology.

> (. . .) I had dengue in 2002. Back then, I was already a professor at the university and at that moment, I realized that there was a huge gap in knowledge related to the diagnosis of dengue, you are at the mercy of chance. (. . .) From then on, I began to research about dengue and drew up the first scientific project (Scientist's account).

With this decision, the Scientist has engendered a set of scientific practices in order to obtain resources to develop projects aiming to increase knowledge about the diagnostic processes of dengue, as well as to purchase equipment needed for research. For this, the Scientist has created partnerships with the implementation of alliances with other colleagues and research institutions. One of the first alliances in the network articulated by researcher scientist was among the R&D Laboratory at the UECE Human Biochemistry, institutions participating in the RENORBIO and the actor represented by the Institute of Tropical Diseases Evandro Chagas, located in Belém City.

> (. . .) In 2002 I didn't have a sufficiently organized laboratory yet, nor did I know colleagues from specific areas related to the diagnosis of dengue. Then I began to bond with researchers in the area and contacted the principal investigator of the Evandro Chagas Institute in order to share with him some research ideas. Thus, two researchers at the lab, our own students, were doing an internship in molecular biology at the institute (information obtained in an interview with the Scientist).

In the same year 2002, they approved the financing of the first project related to the early diagnosis of dengue, entitled "Development of serological techniques for the diagnosis of dengue." For its development, apart from the Institute of Tropical Diseases Evandro Chagas, alliances have been formed

with the Foundation for Research Support of the State of Ceará – FUNCAP and the LACEN – Lab provided the first viruses for laboratory testing.

> (. . .) At that time, I drew up the project and contacted the LACEN (. . .). From this project several scientific collaborations were born. Because I was there, I presented the project and talked to several colleagues. My attitude toward research was to seek partnerships. (information obtained from the interview with the Scientist).

This set of episodic actions shows identification and enlistment of new supporters with redirection of interests, thereby increasing the complexity and margins for negotiation (Latour, 2001). In this sense, the reports suggest that the alliances initiated in 2002, once provided autonomy and continuity to the research from its design and development, initiated the forming of the fifth circuit – *bonds and links* – the circulatory system of scientific facts. According to Latour (2001), the Fifth Circuit, for being a central point in the network that connects to the four other circuits, holds together many resources – projects, ideas, alliances, associations, partnerships, institutions, research, viruses, tests, resources, colleagues, laboratories, and equipment - resulting from different heterogeneous materials that have been collected and managed together (Callon, 1986).

Concept: design and technology development

The organization of scientific practices related to the concatenation of alliances in translations among human actors (peers and institutions) and non-human (projects and equipment) involved in the design and development of biotechnology, enabled the purchase of new materials for the laboratory such as specific pipettes and some electrophoresis equipment, thus providing the development of more comprehensive basic research. The reports reveal the importance of symmetrical combination of human and nonhuman actors from the first circuit of the *World Mobilization*, and *Autonomy* circuits (peers) and *Alliances* (allies) for the design, development and the very continuity of arguing in favour of the research.

> (. . .) From these meetings with colleagues, it was proved that the dengue research field was very dry and there was a huge gap with regards to research. (. . .) Until then the dengue research was focused on the clinical and Brazil was not acting the way we viewed the problem. So, I started the research, first checking the production of antibodies in order to develop a serological technique. I bet on the development of this technique, but as I had few resources, I went on to elaborate the second project (information gathered from the interview with the Scientist).

In 2006, the researcher prepared the 2nd project entitled "Use of plant viruses in the production of proteins for the dengue virus to produce a tetravalent vaccine", submitting it and getting approval from PPSUS – Research Programme which involves institutional alliances at the federal and state levels directed to the Unified Health System (SUS). However:

> (. . .) PPSUS approved the project for the production of antigens, but not for a vaccine for dengue virus using the plant's virus (. . .). The following year, I submitted the project again with some variations and explaining the ultimate intention of producing a vaccine to the FUNCAP – Foundation for Scientific and Technological Development of Ceará, which didn't approve it (information obtained from the interview with the Scientist).

In this sense, during the early stages of the research, the researcher always emphasized the question of how the novelty of the object was a cause of difficulties for the approval, and the consequent autonomy of her idea, at the discredit of some allies, among which, some research development agencies.

> (. . .) At the beginning, during the design of the first phase of this project, I had several dissenting opinions. And so, some projects were rejected, mainly because the idea of the technology to be developed was new. Firstly because the pairs questioned how to produce proteins for vaccine from a plant, then they condemned it by saying, "That doesn't exist. It's impossible!" (. . .) And thus rejected the project (account from the interview with the Scientist).

Considering the tacit character and long-term maturity of projects in biotechnology, a question from the scientist's account stands out when she highlights the controversial position of the allies, such as development agencies, in face of the (lack of) knowledge of biotechnology, especially the one related to the reliability in its degree of novelty (Bonacelli, 1993; Harpum, 2010). Given this uncertainty, the political resolution adopted by the scientist, faced with a set of different interests, was based on the reinterpretation of these controversial interests, with the opening of point crossings, aiming to channel partner actors into new directions (Latour, 2010). The scientist then submitted a third project to a new official announcement, removing from research objective, however, the ultimate intention of producing a vaccine and appealing to less controversial and disputable arguments, as well as translating interests, namely: "This new project was approved and aimed at obtaining material to complete and equip the lab as, for example, to acquire a centrifuge".

The insertion of the centrifuge in the speech, a non-human element, resulted in a change in the resources, once scarce and scattered, highlighting the key role of the *World's Mobilization* circuit, i.e., the tools used for the continuation and autonomy of research. This ultimately enabled the resolution of the dispute between the researcher and her allies (Latour, 2001, 2010), in the Scientist's words. "Then I thought to myself: I get the centrifuge here and acquire resources for reagents in other projects. By doing that, I was able to start working with the already advanced biotechnology in order to produce vaccines with plants."

These episodes reported from the tracking of the controversy related to the design and development of the biotechnology show the blocked paths and shortcuts towards the organization of the network of translations between the stakeholders involved. These passages allowed the strengthening of the Fifth Circuit – *bonds and links* – the circulatory system of scientific facts. As

previously stated, the fifth circuit, being a central point of the network, connects to the four other circuits, among which – the *World's Mobilization*; *Autonomy* (pairs); *Alliance* (allies) and *Public Representation* – keeping together many heterogeneous resources in the network formation of human and nonhuman actors (Latour, 2001).

And at this time, the reports and plots articulated showed the concatenation of the *Public Representation* link, which refers to the need of the researcher to have important relations with the public opinion, such as the press, the media, and citizens, with a view to overcoming the doubts and increasing the reliability concerning the research and correlated knowledge, thus thereby enhancing the persuasive power of the researcher (Latour, 2001).

> (. . .) One day in 2007 we were contacted by Globo Television Network (Rede Globo) for an interview on a program about Science & Technology. The program with my interview was broadcast by Rede Globo on 27 October 2007. At that time, already worked at RENORBIO (. . .) and we were widely developing the project of plant vaccine, and it was at this time, at this stage of project, that we started to appear publicly and in the national media. (. . .) Coincidentally, in 2007, a major dengue epidemic broke out in Brazil, and that prompted Rede Globo to look for research institutions in Brazil in order to identify research groups working with the dengue problem. So, they reached us and Rede Globo contacted me and sent a team here to record an interview with us here in our lab. Also, I realized that the impact of the project at the national level caused even "admiration" from the allied institutions, as we began to massively appear in the media such as Rede Globo, Brasiliense TV, Minas Gerais, Rio de Janeiro and Paraná Radio Stations (information obtained from the interview with the Scientist).

Finally, in 2007, with a view to obtaining new resources, a new project published in an announcement of CNPq was submitted, expanding the network of scientific facts through associative practices and alliances with other scientific laboratories and funding institutions. The reagents achieved in this project (not human actors) were fundamental for the standardization of the experimental techniques, thus constituting a key actor for the development of the technological concept and, consequently, the autonomy of research (Bonacelli, 1993; Latour, 2001; Rabinow, 1999).

The accounts above relate to controversial alliances between human and non-human actors articulated by the scientist in forming a network (Fig. 1), such as: approved (and non-approved) projects in public notices of funding agencies, researchers 'scholarships, the results achieved through associations with other groups and research institutions, public impact, revealing the importance of the funding obtained through the subtle control of movements of objectors as the ones against laboratories and funding agencies.

Experimental system: patenting and technology commercialization

Regarding the development of R&D projects in biotechnology, some authors argue that the greatest challenge to overcome is the implementation of effective management tools which assist the development and places it on the market. On the other hand, with regards to the products generated by research into biotechnology, patents are an effective strategic tool in this type of industry for organizations to protect and take possession of the benefits of R&D and promote innovation for the general market. It is noteworthy that, in addition to involving the possibilities of

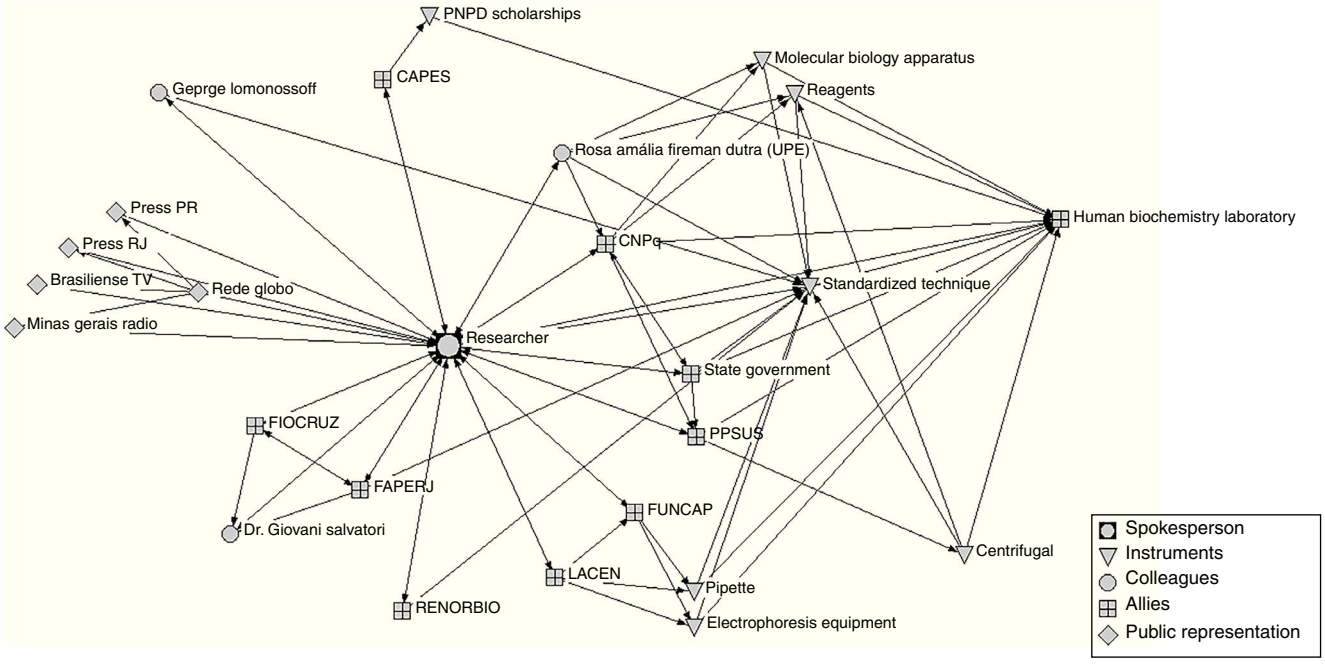

Fig. 1. Alliances built in the historical episode of the design and biotechnology development.

Source: Empirical research.

patents, biotechnology products must also satisfy the criteria of novelty, utility and validation, which are common to all patent registrations (Grace, 1997; Harpum, 2010).

In line with this argument, the patent application related to the biotechnology object of this study was submitted in February, 2011. Then, the technology protection process was coordinated by a new ally, the Innovation Centre of the State University of Ceará – NIT/EC, and subsequently shared with the alliance signed with the Technological Innovation Network Centre of the State of Ceará – REDENIT-CE. The submission of the patent application impacted the mainstream media again at national level, consolidating the circuit of public representation of the circulatory system of the scientific facts (Latour, 2001). "(. . .) With the submission of the patent, we didn't expect all that hype. (. . .) I was again approached by journalists from all over Brazil, major newspapers such as Folha de São Paulo" (account from the interview with the Scientist).

The beginning of the alliance between the researcher and the NIT dates back to March of 2008. This was the year in which the NIT coordinator instilled in Ceará State University (UECE), a member of RENORBIO, the idea originated from the hybrid culture of academic research environment with a business view. In an interview, the Coordinator of REDENIT-CE recalls this period:

> (. . .) When I arrived at the NIT in 2008 there was no patent or intellectual property policy, of R & D protection with a view to innovation, so I tried to merge this view of academic culture with a business vision. Between 2009 and 2010, there were many cultural shocks, as there was a practice which prevented innovation, focused solely on publication and not patent of R&D. So, my first task at the NIT was to contact the key-researchers, among which the RENORBIO, to disseminate the technological processes in a faster way (Interview with the REDENIT-CE Coordinator).

During this period, the NIT focused on alliances with researches who were opinion makers, those who developed R&D at RENORBIO the most. From the Scientist's point of view, the beginning of the alliance with the NIT was quite controversial.

> (. . .) In the beginning, implementing the NIT here at the University, was, in my opinion, quite troublesome. In fact, I didn't even know about the existence of the NIT and when my first break to make my first patent come about, wanted was to convince the NIT that we needed some support, an office would write our patent. Because, in my opinion, despite its competence, the NIT lacked a larger structure for this (account obtained from the interview with the Scientist).

During the controversial translations of the patent process, between the years 2009 and 2010, REDENIT-CE was created. Upon receipt of funds from a local development agency in June 2010, REDENIT was able to be structured, thus filling some holes in organization and structure faced by the NIT. The allocation of these resources allowed for the patenting of 46 technologies from 17 R&D institutions participating in the REDENIT by hiring a specialized law firm. Thus, the process of patenting the biotechnology under study, as well as the protection of the other 45 protected technologies, were only made possible through the interaction and translations of interests and resources across heterogeneous multi-agents (UECE, RENORBIO, NIT, REDENIT, FUNCAP, notices and various resources, R&D institutions, specialized law firms, patented technologies), consolidating the central point of connection with other circuits of the Circulatory System of Scientific Facts – *World's Mobilization*; *Autonomy* (pairs); *Alliance* (allies) and *Public Representation* (Latour, 2001).

Another important episode refers to the entry of a new actor – Oswaldo Cruz Foundation (FIOCRUZ), into the circuit, which occurred after the public impact of the filing of the technology patent. FIOCRUZ contacted the scientist so as to get to know the patented biotechnology better. Regarding the biggest obstacle to overcome, namely, the implementation of effective management tools that help R&D and put a new technology on the market (Harpum, 2010), it was proved from the interviews with the scientist and the REDENIT coordinator that, for the commercialization of the biotechnology, it is important to search for new alliances, targeting new studies of R&D, especially those related to clinical trials. Given this and in view of the commercialization of the biotechnology, there was a discussion with FIOCRUZ about the development of a project aimed at carrying out clinical trials, since this institution has an important infrastructure to realize this project.

The negotiations with FIOCRUZ are still under way, especially regarding the need to conduct clinical trials, which is one of the most costly and controversial demands for a new technology reaching this stage. In this sense, the network-of-actors, until now organized around the R&D Laboratory under study, has not yet gathered enough scientific, economic and political alliances for the organization of scientific practices related to the development of clinical trials. However, these associative movements triggered transformations in order to enlist new actors and entities, extending the network-of-actors and reorganizing a new topography of this social.

The reports reveal that efforts are being made with the involvement of new ally actors in the network, such as the State Government of Ceará, aiming at the renovation and expansion of the R&D laboratory. These are necessary conditions to stimulate the alliance with FIOCRUZ at this historical stage. Despite the new challenges arising from the reorganization of the network (Fig. 2) from the creation of new alliances with different institutional actors, the translations involving the Scientist in association with the NIT and REDENIT-CE resulted in the development of different strategies geared towards new alternatives for the commercialization of various biotechnological processes.

Among these strategies is evident the exploitation of new business opportunities, by the opening of a new market space from the creation of an emerging spin-off type company – the Greenbean. A new actor came up with the aim of creating alternative conditions to parts of the developed biotechnological knowledge reach the market, reducing the gap between the research carried out by a member of R&D institute an academic network and related productive sectors (Nelson, 2006).

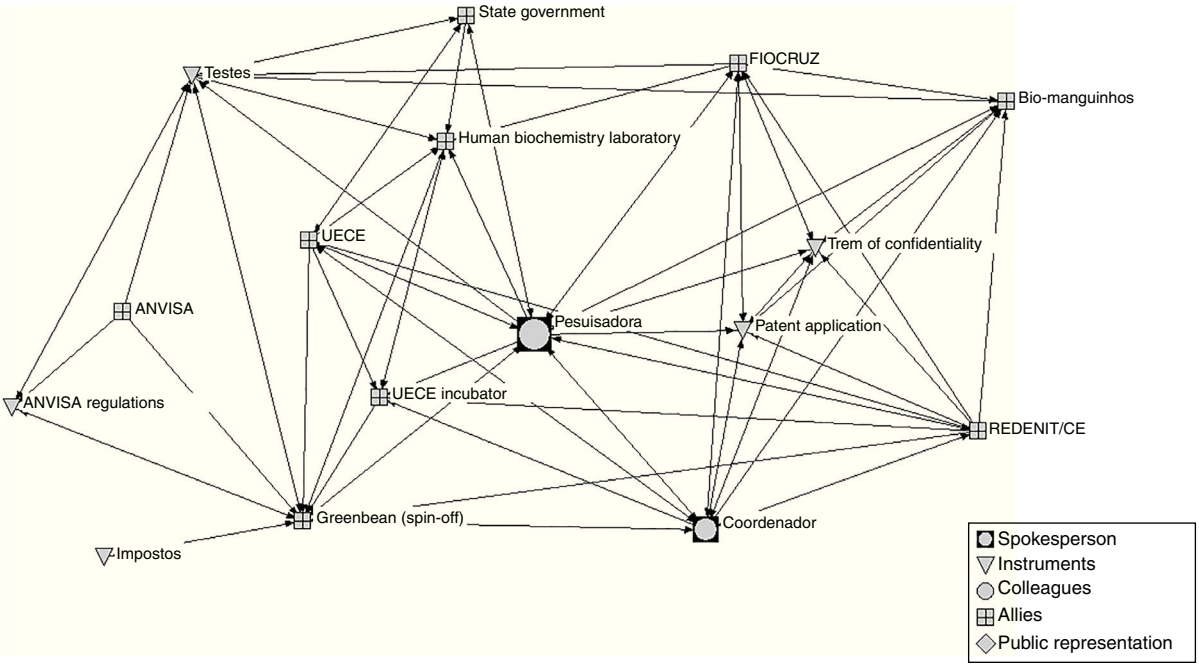

Fig. 2. Alliances built in the historic episode of patenting and possible commercialization of biotechnology.
Source: Empirical research.

Final considerations

In the mid-70s, a group of British scholars, among whom were Barry Barnes and David Bloor, confronted the sociology of science developed under a functionalist basis by Robert Merton with a critical discussion of the constructivist analysis of Social Sciences, focusing on the everyday informal practices that took place within the scientific laboratories (Latour, 1997; Lynch, 1993). In this sense, scientific studies illuminate the organizing practices, focusing scientist at work in contrast to the histories of the ideas and the structure of science institutional theories (Knorr Cetina, 1999; Latour, 1997).

Based on this discussion, this study aimed to contribute to a broader empirical approach to make use of the assumptions of the ANT, combined with a historical analysis, in what concerns the understanding of the organizing of scientific practices which based R&D efforts in a laboratory of the Northeast Biotechnology Network – RENORBIO, where the biotechnology "Vaccine Development Using a Bundle as Bio factory" was conceived.

These procedures enabled the authors of this research to follow the enrolment and entanglement between the actors – human and nonhuman – which moved and transferred their controversial interests by setting up different networking practices in constant definition, redefinition and transformation, ultimately revealing the connections between a scientific, political, economic and ecology in the organization of the related scientific practices.

As a result of the historical description of the stages of design, development, patenting and marketing of the biotechnology under study, we can draw attention to the practices arising from the controversial translations covered by the scientist and his allies, actors – human and nonhuman – in the conjunction of an intricate symmetrical and contingent network. These pathways shed a light on the issues related to the ability of an inventor to take control of the return of his invention and the effects of that effort in R&D concerning the demand for innovation.

These scientific practices which are defined, mobilized, exchanged and negotiated through time and space by the successive alliances built between the different actors-network, revealed the forms of organizing as the scientist's leadership effect – R&D RENORBIO lab Coordinator, among which: (i) the practices regarding the inclusion of non-human actors in the speech, arguing in favour of biotechnology and ensuring the standardization of experimental techniques; (ii) the translations which enabled the organization of symmetrical alliances between scientific, political and economic practices, ensuring the autonomy, continuity and development of a more comprehensive biotechnology; (iii) the concatenation of the link related to the practices of *Public Representation*, overcoming doubts, ensuring the reliability concerning biotechnology and expanding the power of persuasion of the scientist; (iv) the translations in network which resulted in the practices of patent protection and the creation of a new actor, an emerging company in the spin-off type of biotechnology.

As implications of this study, some important issues were highlighted, among which those related to Science and Technology Management in the strategic formulation of policies that promote the acceleration of the innovation cycle which leads, from the discovery and invention to making goods and services available to society. That is especially true in the biotechnology area, when highlighting the risks and uncertainties, high research and development investments (R&D), involving new and non-standardized technologies full of tacit and multidisciplinary knowledge.

In this sense, it is important to provide the patenting conditions of biotechnology as an effective instrument in this sector, so that organizations and partner actors can protect and own the benefits of R&D, exploring new business opportunities, primarily through thriving companies like biotech spin-offs, building bridges and reducing the gap between the research developed at the scientific R&D institutes and the productive sectors.

Considering the results of this research, it is suggested that future studies should also focus on controversial alliances related to participating actors of the stages pertaining to conducting clinical trials of promising biotechnology patents, especially by including the controversial translations with large pharmaceutical corporations and other related issues. In this context, it is important to broaden the discussion of the actors-network, by shedding light, specifically, on issues concerning the power between these actors. These discussions could be based on the steps of the translation process, suggested by Latour (2000) in his book 'Science in Action', expanding and going beyond the model comprised by "five circuits" used in this study (Latour, 2001). Finally, a theme to be deepened in future studies refers to the evidence about the ways of organizing as an effect of the leadership of the laboratory chief Scientist. In this regard, we highlight Knorr Cetina's discussions (1999) on the forms of transition in order to become a leading laboratory, including the development of the scientist's leadership process.

Thus, it is expected that further studies can deepen the analysis carried out in this research, identifying new human and nonhuman actors-networks and analysing the hybridization of several scientific dimensions, existing political and economic relations between them in forming a network of practices, for example, at the translation stage and/or spread/transfer of technology to the market in the form of innovations.

Finally, this study also contributed to a deeper understanding of the organizations as a diffuse and procedural phenomenon. This perspective leads to viewing the organization as something not behind closed doors, already established, but rather as open processes in constant construction.

Moreover, we highlight that the sociological analysis that was based on an ethnographic posture and, above all, historical plots produced at the R&D developed in the biotechnology sector is by no means an exhausted subject. In this regard, this research is an initial effort to build this interdisciplinary field to articulate other approaches, such as sociology and history in the field of Organizational Studies and Administration.

Conflicts of interest

The authors declare no conflicts of interest.

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